A Summary of Current Program and
Preliminary Report of Progress

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1962

SHEEP AND WOOL RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

December 1, 1963

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Soil and Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer and Food Economics
7 - Animal Husbandry
7 - Animal Disease and Parasite

Agricultural Marketing Service (AMS)

4 - Market Quality
4 - Transportation and Facilities

Economic Research Service (ERS)

4,5 - Marketing Economics
5 - Farm Production Economics
5 - Resource Development Economics
5 - Economic and Statistical Analysis
5 - Foreign Development and Trade Analysis
5 - Foreign Analysis Division

Other Services

1 - Soil Conservation Service (SCS)
4,5 - Farmer Cooperative Service (FCS)
4,5 - Statistical Reporting Service (SRS)
6 - Forest Service (FS)

Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering
Crops
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

1 - Cross-Commodity Research of Agricultural Engineering, Crops, & Entomology Research Divisions
3 - Rural Dwellings
6 - Forestry (Other than Forest Service)
7 - Beef Cattle
7 - Dairy
7 - Poultry
7 - Sheep and Wool
7 - Swine
7 - Cross-Specie & Miscellaneous Animal Research
8 - Cotton and Cottonseed
8 - Tobacco
9 - Grain and Forage Crops
10 - Citrus and Subtropical Fruit
10 - Deciduous Fruit & Tree Nut
10 - Potato
10 - Vegetable
10 - Florist, Nursery & Shade Tree
11 - Oilseed and Peanut
11 - Sugar

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

This report on sheep research covers work directly related to the production, processing, distribution, and consumption of sheep, lamb, wool, goats and mohair. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only sheep problems but also to the problems of other commodities. Progress on cross-commodity work is found in the reports of the several divisions such as Soil and Water Conservation, Human Nutrition, Transportation and Facilities, Farm Production Economics, Foreign Development and Trade Analysis, and Cross-Specie and Miscellaneous Animal Research.

This report is devoted to the 15 "problem areas" shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA Program, (3) A summary of Progress during the past year on USDA and cooperative work, and (4) A list of Publications resulting from USDA and cooperative work.

Sheep research can be divided into three major categories, i.e., that supported by (1) Federal funds appropriated to the research agencies of the United States Department of Agriculture, (2) Federal and State funds appropriated to the 53 State Agricultural Experiment Stations, and (3) private funds allotted, largely by the sheep industry, to research carried on in private laboratories or to support of State Station or USDA work. For all three categories it is estimated that about 300 scientists are engaged in research dealing specifically with the production, processing, distribution, and consumption of sheep and wool. Support of their work involves an annual expenditure of between 7 and 10 million dollars. This amounts to about 1.0 percent of the cash farm receipts from sheep and wool and about 0.5 percent of the retail value of meat and wool. Of the 300 scientists engaged in sheep and wool research, approximately 33% are employed by the Department of Agriculture, 25% by the State Experiment Stations, and 42% by other universities, foundations, and private industry.

Research by USDA

Farm research pertaining to sheep and wool is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, diseases, parasites, housing and management, involving 44 professional man-years of scientific effort.

Nutrition, consumer, and industrial use research pertaining to sheep and wool is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, Clothing and Housing, Eastern Utilization and Western Utilization. The work on meat comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions. Work on wool pertains to fabric and textile performance. Research pertaining to the processing phase involves slaughtering the animals and processing the meat and the wool. Also, it is concerned with improved equipment and processes. The work in these divisions involves 50 professional man-years of scientific effort.

Marketing and economic research pertaining to sheep and wool is carried on within four Services: Agricultural Marketing Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing; and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, AMS; Transportation and Facilities, AMS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS. The scientific effort involved by these divisions amounts to 6 professional man-years.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects sheep and wool research is carried on by most experiment stations in States where sheep and wool are important. The types of work to which the largest amount of effort is devoted include efficiency of production, diseases and parasites, and marketing. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

The production research conducted by industry is done primarily by large commercial ranches in the West and pharmaceutical manufacturing companies. The size of flocks needed and effort involved for evaluating breeding practices has rested largely with publicly supported institutions, and with the cooperation of owners of private herds. The effects of hormone and hormone-like substances alone or in combination with antibiotics on growth and physiological reaction of sheep is being studied by a few pharmaceutical companies.

The research in utilization and marketing conducted by industry, which is applicable to sheep, goats, wool and mohair, is not clear cut. The animals and their products are merged with other species and products at auction and terminal markets in processing plants, and on through the marketing channels, and research emphasis pertains more to functions than commodities.

With mill consolidation in recent years industrial research on wool has practically disappeared. With the advent of synthetic fibers what was formerly a wool-processing industry lost interest in wool per se and undertook processing of the particular fibers that were in demand. Processors of the synthetics conducted the research needed to adapt the wool machinery to process synthetics and provided the information to the industry. This development in combination with a serious decline in the financial strength of the wool industry resulted in a shift of scientists from wool research to quality control, mill troubleshooting and short-range developmental work. Industry application of research developed by public institutions is done where it has a potential of profit.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Higher reproductive rates from crossbreeding of sheep. Crosses of Hampshire, Shropshire, and Merino sheep at Beltsville have shown that reproductive efficiency was higher for crossbred than for purebred matings. Furthermore, there was an upward trend with an increase in the number of breeds involved in the cross. Average increases in percent lambs weaned of ewes bred were 2.1, 14.9, and 27.1 for 2-, 3-, and 4-breed crosses, respectively, over the comparable averages of the purebred parents.

Ram behavior studies aid in sheep improvement. Studies at Dubois, Idaho, have shown that when more than one ram is used in breeding a group of ewes an order of dominance is quickly established. Mature rams were always dominant over yearling rams. In rapidly improving flocks yearling rams are often genetically superior to older rams. Thus, the use of dominant rams of inferior genotype could greatly affect

the average merit of the lamb crop. Also, dominant rams which happen to be sterile or of low fertility could greatly reduce the lamb crop and extend the lambing season.

Microbes help with pesticide residue problems. Ruminal protozoa, cultured as individual species, offer definite promise as a screening technique for determining if pesticides will leave residues in meat and milk of cattle and sheep. Ruminant animals possess large numbers of microorganisms in their digestive system, particularly the rumen which appears to be the natural site for the microbial degradation of complex compounds such as pesticides. Pesticides, if degraded in this manner, will not produce residues in the meat even though they are consumed with the feed. Ruminal protozoa were found to metabolize the following pesticides: Diazinon, dimethoate, lindane, Thiodan, and Sevin.

SHEEP AND GOATS - BREEDING
Animal Husbandry Research Division, ARS

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, as well as on the inheritance of feed efficiency, rate of gain and carcass quality deserve emphasis. Basic research on the inheritance of blood antigens is needed to implement other sheep genetic studies.

USDA PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Inheritance of blood antigens is being investigated in cooperation with the California Experiment Station. Cooperation is maintained with 15 other State experiment stations. Several of the studies contribute to the western, southern and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.5 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Environmental interactions. Because proper interpretation of important environmental effects on various performance traits is dependent on knowledge concerning the presence or absence of interactions among the different categories of effects, the importance of two-way environmental interactions was examined on 39 weanling and yearling traits of 4452 Rambouillet, Targhee and Columbia ewes at Dubois, Idaho. The most important interaction discovered was that between year of record and band in which

the lamb was reared. This interaction was significant for approximately 50% of the 14 weanling traits examined and 10% of the 25 yearling traits examined. The next most important interaction was that between year of record and type of birth and rearing, which affected about 8% of the weanling traits and 12% of the yearling traits. The two least important were those between age of dam and band and those between age of dam and years; the former affecting only 2% of the weanling traits and 5% of the yearling traits involved. Other interactions examined were between type of birth and rearing and age of dam and between type of birth and rearing and band. In general, interactions involving years were most important and those involving age of dam were least important. It appears that the magnitudes of many environmental effects are conditioned by the year in which the effects occur. This emphasizes the importance of making breeding tests and comparisons over a period of years. Also, where important interactions occur, adjustment factors must be determined each year. (AH b1-6)

2. Heritabilities and phenotypic, genetic, and environmental correlations. Heritabilities and correlations among eight weanling traits of Rambouillet, Targhee, and Columbia topcross lambs were examined at Dubois, Idaho, in cooperation with Montana State College, Bozeman, Montana. Estimates of heritabilities in the three breeds ranged from 17 to 25% for weaning weight, 53 to 100% for face cover, 0 to 50% for neck folds, 1 to 55% for body type, 16 to 40% for condition (fatness), 10 to 72% for staple length, 19 to 62% for wool grade, and 0 to 31% for crimps per inch. Phenotypic, environmental, and genetic correlations among weaning weight, type, and condition were all moderately large, generally above 0.5, the heavier animals having better type and condition both phenotypically and genetically. However, because of the generally low heritabilities for all three traits, mass selection for any one is unlikely to importantly influence either of the others genetically in all three breeds. Genetic improvement in weanling staple length is likely to be accompanied by a genetically coarser wool grade at weaning (genetic correlations being 0.6 or higher whereas phenotypic correlations are all less than 0.6). Because heritability for staple length in Rambouillets is appreciably higher than for side grade, mass selection on staple length in this breed would be slightly more effective in changing side grade than selection on side grade itself. Most other genetic correlations among the eight traits are unimportant or the sampling errors are obviously so large as to render the interpretation questionable. Important environmental correlations between body type and staple length, and between crimp and staple length cause phenotypic correlations to be higher than comparable genetic correlations would indicate. (AH b1-6, AH b1-14)

At Fort Wingate, New Mexico, data on 1075 yearling ewes were analyzed to obtain heritability estimates, genetic and phenotypic correlations among seven traits: body weight, body type, body condition, staple length, fiber diameter, grease fleece weight, and clean fleece weight. The ewes were from three separate breeding groups of improved Navajo and Navajo crossbred types and were born over the 14-year period 1947-1960.

The three body traits (body weight, body type, body condition) were found to have moderate to high genetic and phenotypic relationship. Highly significant positive phenotypic correlations were obtained among the fleece traits (staple length, fiber diameter, grease fleece weight, clean fleece weight). The most important genetic correlations among the fleece traits were 0.93 between grease fleece weight and clean fleece weight and 0.44 between staple length and clean fleece weight. The genetic correlation of -.24 between staple length and body weight appeared to be the only one which would handicap selection. The genetic relationship between clean fleece weight and fiber diameter was found to be negligible. Heritability estimates fell in the moderate range (0.20 to 0.40) for all but two traits: body type (0.17) and clean fleece weight (0.19). (AH b1-10, AH b1-11, AH b1-12, AH b5-6)

3. Correlation among traits. Analyses at Dubois, Idaho, of 5 year's data obtained on the efficiency of gain of 226 individually fed Rambouillet ram and ewe lambs (39 traits) and a comparable lot of 218 group fed lambs (23 traits) have provided additional estimates of the effects of age of dam, type of birth and rearing, sex, band and age of lambs, on efficiency of feed conversion and rate of gain on feed test. Phenotypic correlations, independent of measurable environmental effects, were calculated among all traits studied. Feed lot performance traits significantly correlated with efficiency of gain included rate of gain (-.62), initial body weight (.40), initial type (-.22) and initial condition (-.16). No significant correlations were found between feed efficiency and the remaining feedlot performance traits (daily feed consumption, final type, final condition, and increase in wool staple length during the test period). Correlations between efficiency of gain and birth, weaning and yearling traits were low and most lacked statistical significance. Rate of gain during the test was significantly correlated with daily feed consumption (.78), final body weight (.55), grease fleece weight (.35), yearling body weight (.33), gain from birth to weaning (.24) and variability of fiber diameter (.21). Rate of gain was not significantly correlated with any of the other traits studied. Estimated heritability of feed efficiency for the first 42 days, second 42 days and 84 days on the feed test was .65, .35, and .26, respectively. (AH b1-13)

4. Factors affecting rate of gain in lambs. A study was conducted at Fort Reno, Oklahoma, Livestock Research Station, to determine the consistency of differences in gain in weight from about 50 to 90 pounds between classifications of birth weight, breed of dam, birth and rearing type and sex for lambs from the same group of ewes in different years. Seven separate analyses were made for each of the four years involved with different combinations of the above classifications. The constants obtained for birth weight changed very little from year to year regardless of the other variables included in the analyses. The magnitude of the differences of the estimates of daily gain due to birth weight increased each year as the ewes became older. Estimates of the difference in daily gain due to type of birth and rearing changed rather drastically from year to year.

The constants obtained when birth weight was omitted from the model were also different than when it was included as a variable. Constants obtained for sex differences also increased as the ewes became older or with time. These constants changed with the inclusion of birth weight in the analysis which indicated a correlation between the two variables. This study indicates that the accuracy of adjustment factors may be improved if obtained from a least squares analyses and containing only the sources of variation for which adjustments are to be made. (AH b3-7)

5. Investigation of blood group relationships in sheep. Cooperative work with the University of California at Davis, concerned with blood groups in sheep, has been continued. California workers first diagnosed the occurrence of a freemartin ewe in 1953 on the basis of having red cells of two distinct types which she shared with her co-twin, a ram. Three such cases of freemartin ewes have now been diagnosed and confirmed in the University of California sheep flock. It appears that either freemartin occurs in sheep much more frequently than is generally supposed or that the University flock is somehow predisposed to producing freemartins.

A total of 21 additional isoimmune antisera was produced and collected during the year to replenish the stock supply of certain reagents. A new reagent prepared from an isoimmune antiserum coded S106 was found to be reactive in the M system of ovine blood groups. Its reactions permit definition of a new phenogroup designated M^1 corresponding to the name given the reagent.

Some 5,185 statistical tests involving four years of data from sheep at Davis and Hopland, California, and Dubois, Idaho, on relationships of blood types with production traits have been made. The analyses have as yet shown no consistent trends in all years within a breed or in all years between breeds for any of the various combinations of blood types and production traits under comparison. On the other hand, genotypes of three blood group loci, namely, A, D and R-O, appear to be clearly associated with certain components of fitness, namely, ovulation rates, conception rates, and both prenatal and postnatal lamb mortalities. (AH b1-15)

B. Selection and Systems of Breeding

1. Breed comparisons and crossbreeding. This work was undertaken at Beltsville, Maryland, to compare breeds with respect to their ability to produce wool and lamb, and their relative merit in a crossbreeding program. Specifically this report covers that portion of the study dealing with the effect of crossbreeding on weaning weight, birth weight and gain from birth to weaning. This work includes a total of 4331 lambs born and 3423 lambs weaned during the years 1952-1961, inclusive. It involves data from four purebred groups of sheep including Hampshire, Shropshire, Southdown, and Merino and one strain evolved from a Columbia-Southdale cross. The work also includes seven groups of first or 2-breed cross lambs from Hampshire, Shropshire, and Southdown rams and from Hampshire, Shropshire, and Merino

ewes; 15 groups of 3-breed cross lambs from 2-breed cross ewes and purebred sires of Hampshire, Shropshire, Southdown, and Merino breeding, plus two groups of lambs sired by crossbred rams and from Merino ewes. Six groups of 4-breed cross lambs were from 3-breed cross ewes and from Southdown and Merino sires.

From a detailed analysis of factors affecting birth weight, weaning weight and daily gain, it was found that years, sex, type of birth, age of dam, and breeds and crosses all had significant effects on birth weight. The interactions involving sex X years, sex X type of birth, sex X age of dam, and sex X purebred or crossbred were all non-significant. For weaning weight it was found that years, sex, type of birth and rearing, age of dam, the regression of weight on age, and breeds and crosses all had significant effects. It was also found that the interactions of years X sex, sex X type of birth and rearing, sex X age of dam, sex X purebred or crossbred, sex X high or low year, age of dam X high or low year and the regression due to date of birth were all found to be significant except years X sex and sex X age of dam.

The purebreds ranked in the same order for both birth weight and weaning weight, with the Hampshires highest, followed by the Columbia-Southdale, Shropshire, Merino, and Southdown. The pure breeds also ranked the same for gain from birth to weaning except that the gain for the Southdowns was slightly greater than for the Merino, but their difference was not significant. The two-breed cross offspring tended to rank in the same order for all three traits as the purebred lambs from the dams breeds. The offspring also tended to rank in the order of the sire breed within a dam breed, although there were some exceptions. Differences between crosses were not so readily apparent within 3-breed and 4-breed crosses. Offspring from crossbred rams mated to purebred ewes excelled over the purebreds, but not over offspring from purebred sires mated to crossbred ewes. Advantages of all crossbred lambs over purebred lambs involving the same breeds were 7 pounds for weaning weight, 0.63 pounds for birth weight, and 6.5 pounds gain from birth to weaning. Crossbreds always excelled over the comparable averages of the purebreds making up the cross for each trait. The average gain in weaning weight over the purebreds was 5.2 pounds for the 2-breed cross, 9.5 pounds for the 3-breed cross, and 10.4 pounds for the 4-breed cross. (AH bl-1, AH bl-2, AH bl-3, AH bl-4)

2. <u>New strains of sheep for lamb and wool production.</u> In many areas of the United States it would be advantageous if lambs could be produced at any time of the year. However, this is not feasible now as our present domestic breeds do not reproduce in abundance except during the winter and spring. More intensive and more efficient lamb production, especially in farm flocks, would be greatly facilitated by strains of sheep which would efficiently reproduce every 6 to 8 months and do this without seasonal restrictions. Thus, work has been started at Beltsville, Maryland, on the development of a strain of sheep capable of reproducing more than once per year. The development of such a strain of sheep will demonstrate the

effectiveness of selection in changing reproductive frequency and in removing seasonal restrictions on reproduction. The present plans envisage the development of a complete reproductive cycle each 8 months resulting in three lamb crops in two years. Matings are made in April, December and August and the lambs are weaned at about 60 days of age in December, August and April.

To date 168 ewes have lambed and 156 lambs have been weaned. There is considerable annual variability in fertility and lamb mortality particularly for September lambing. A total of 15 ewes each lambed three times in the first two years weaning 53 lambs. Present sires were born in the first fall lambing from mothers which each have since lambed three times in two years. (AH bl-17)

3. Comparisons of breeding systems. Preliminary results at Dubois, Idaho, based on weanling progeny from 46 Targhee and 26 Columbia sires randomly selected from the upper and lower halves of each breeding group and tested on an unrelated tester stock (eight test ewes per sire) show inbred Columbia sires to be only slightly better than purchased, stabilized control, and selected control sires for both weaning weight and overall merit (index). The superiority in overall merit was due principally to differences in weaning weight. The range from poorest to best system was 6 pounds in weight and 2.5 points in index. In the Targhee, selected control sires were superior in both weaning weight and overall merit, the superiority in weight being negligible. The range from poorest to best system was only 4 pounds in weight, but 12.8 points in merit. The superiority in merit was due principally to more open faces, less wrinkled necks, and slightly longer staple lengths. Recurrently selected inbred sires were second in overall merit, chiefly due to longer staple lengths. Stabilized control and purchased sires were poorest and about equal in overall merit, although weaning weights from purchased sires were equal to those of selected control sires.

When the evaluations of the systems were based upon offspring produced entirely within the system, i.e., produced by both sires and dams from within the system, the earlier pattern of selected control superiority and inbred line inferiority was clearly repeated in all three breeds (including Rambouillets) with the stabilized controls ranking near or slightly above the inbred lines in weaning weight and overall merit. However, the stabilized controls distinctly surpassed the inbred lines in pounds of lamb weaned per ewe bred by from 6 to 16 pounds. Comprehensive line cross information from nearly every Targhee and Columbia line placed the line cross offspring on a par with the selected control in both average weaning weight and overall merit. The pounds of lamb weaned per ewe were about 16 pounds less in the Targhee line crosses than in the selected control although unimportantly superior to the selected control in the Columbia line crosses. Line cross and inbred line production each were adjusted for the effects of inbreeding of the dams. These results tend to contradict earlier line cross results

based on crosses from only 1/3 to 1/2 of the lines in each breed which generally placed the line crosses in an intermediate position.

Production indexes for mature ewes based on lifetime average annual pounds of lamb weaned per ewe bred plus three times the average grease fleece weight give control ewes (including both selected and stabilized control) a 22 point advantage in Rambouillets, a 9 point advantage in Targhees, and a 9 point advantage in Columbias over the inbred line average. (AH b1-5)

4. Testing of inbred lines. The first year's data have been obtained on a comprehensive line testing program at Dubois, Idaho. The data include results on topcross and linecross weanling progeny from 40 Targhee and 20 Columbia sires (randomly selected) representing 20 Targhee and 10 Columbia inbred lines at Dubois.

Results from Targhee topcrosses on an unrelated tester stock ranked lines 8T, 15T, 14T, 5T, 20T, 1T, and 17T in the order given as being the top third for overall merit (index). These lines ranged from 155.71 to 151.42 in average index, with the average for all Targhee topcrosses being 148.45. The linecross results ranked lines 17T, 14T, 7T, 1T, 12T, 15T, and 3T as the top third; with indexes ranging from 168.03 to 161.76. The average index for all Targhee linecross progeny was 160.74. Indexes for all linecross progeny were adjusted for the inbreeding of the dams. Lines 17T, 14T, 15T and 1T were among the top third in both tests.

The top third of the Columbia topcross results include lines 9, 7, 8, and 5, with indexes ranging from 148.12 to 144.50; 143.47, being the mean of all Columbia topcross progeny. The Columbia linecross progeny ranked lines 5, 6, 2, and 7 in order as the top third with indexes ranging from 148.80 to 147.69; the overall mean for Columbia linecrosses being 146.72. Note that lines 5 and 7 were common to both groups in these independent tests for general combining ability.

It was noted that the correlation between each line's own merit as an inbred line and its response in top and linecross tests was only moderate to low. (AH b1-5, AH b1-14)

5. Selection for range sheep improvement. Research on the rate of improvement in wool and lamb production resulting from a practical breeding and selection program under range conditions is being investigated at the Redd Ranches, La Sal, Utah, in cooperation with the Utah and Colorado State Experiment Stations.

A super flock initiated with approximately 1000 ewes selected from the entire flock of over 15,000 ewes, was set up in 1957. Selected rams were originally mated to this group and the top rams and ewes produced from the super flock have been used for its replacements since. Rams produced from the super flock are mated to selected bands of ewes from the main flock to produce replacement ewes for the main flock. The remainder of ewes from the main

flock are mated to meat breed sires to produce market offspring.

In the first 3 years from 40 to 49 percent of the ram lambs weaned have been saved for possible use in breeding. Selection differentials in these have ranged from 10 to 11 pounds for weaning weight, 0.09 to 0.14 inches for staple length, and 0.12 to 0.24 score for face covering. Indications of improvement based on yearly trends are evident for weaning weight, staple length, face covering, and polledness. (AH b1-16)

6. Selection of ewes on early production records. Seven years of production records for 167 ewes in the Fort Reno, Oklahoma, experimental flock were studied to determine how the ewes might have been culled during the first year or two of production to create more efficient flock productivity. The production traits studied were whether or not the ewes lambed during the fall of their first, second or both years; their level of lamb production during their first two years; their frequency of raising the lambs produced; the birth weight, 70 day weight and post 70 day rate of gain of their lambs; and the weight of wool produced yearly.

Culling the ewes that failed to lamb during the fall of their first year would not have resulted in appreciable improvement. Culling the ewes that failed during their second year would not have required such heavy culling as culling on first year's performance and would have resulted in more improvement. The data suggested that ewes that failed to lamb during the fall in both of the first two years could be culled with considerable assurance of removing ewes that would be lower-than-average producers for the rest of their lives. Ewes that had twins during either or both of their first two years raised 19 and 33 percent larger lamb crops for the next five years than ewes that did not.

Culling ewes that lambed but failed to raise one or more lambs during their first two years would not have changed the flock productivity appreciably.

The repeatability of birth weight on unadjusted data was low but was moderate when the data were adjusted for the sex, type of birth and age of dam of the lamb and the year in which he was born. The weight of the lamb(s) at 70 days of age and rate of gain from 70 days to market weight (about 90 pounds) were traits of low repeatability in these data and consequently one evaluation of a ewe for these traits would not give one a sound basis for culling.

The repeatability of fleece weight was high when calculated for these ewes plus two groups of Dorset X Rambouillet crossbred ewes that were raised. Thus the culling of ewes that sheared the lightest fleeces would be efficient from the point of view of increasing the weight of wool sheared by the flock but unless light shearing ewes were also poorer than average performers for lamb production, they probably should not be culled. (AH b3-7)

7. Effect of pregnancy and lactation on wool production. A study was completed from Fort Wingate, New Mexico, involving the effects of type of parturition, lactation and subsequent pregnancy on grease and clean wool production. Included were 2424 records of grease fleece weights taken during the years 1955-59 and 1451 clean fleece weights taken from 1957-59. The ewes were sheared just before lambing.

The effects of parturition and lactation upon wool production were very pronounced with ewes giving birth and nursing twin or single lambs producing significantly less grease and clean wool than ewes producing no lambs. The effects of pregnancy were not as pronounced as were those for parturition and lactation. Ewes pregnant with a single lamb did not produce significantly less grease wool than ewes which failed to lamb; however, the difference in clean wool yield was significant.

These results indicate that selection in mature ewes for increased wool production should be made only after adequately accounting for the effects of lactation and pregnancy. (AH b5-6)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelations of Performance Traits

Brothers, D. G., Whiteman, J. V. 1962. Inconsistency of partial regression coefficients for variables affecting lamb rate of gain. J. Anim. Sci. 21(4), pp. 824- 828 (AH b3-7).

Selection and Systems of Breeding

Ercanbrack, S. K., Blackmore, D. W., Van Horn, J. L., Blackwell, R. L., Hoversland, A. S., Kyle, W. H., Drummond, J., Terrill, C. E., and Willson, F. S. 1962. Weanling performance of top cross progeny from inbred and noninbred rams. J. Anim. Sci. 21(4), p. 972 (Abstract) (AH b1-6).

Sidwell, G. M., Everson, D. O., and Terrill, C. E. 1962. Fertility, prolificacy and lamb livability of some pure breeds and their crosses. J. Anim. Sci. 21(4), pp. 875-879 (AH b1-17).

Whiteman, J. V., Harrington, R. B., Nichols, C. W. and Bosler, W. L. Jr. 1963. Which ewes should we cull? Oklahoma M. P. 70, pp. 5-14 (AH b3-7).

SHEEP AND GOATS - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 2.5 professional man-years. Of this number 0.7 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.3 to physiology of wool and fiber, and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Flushing studies with range sheep. Columbia ewes at Dubois, Idaho, were supplemented with 0.5 or 1.0 pound of oats per head per day for 17 or 34 days prior to breeding. Oat straw was used to lower the condition of two of the treatment groups prior to administration of the oat supplement. Results indicate a year x treatment interaction on lamb production. None of the flushing treatment applied in the fall of 1960 resulted in a greater response than the unsupplemented control. In the fall of 1961, following fall rains which produced a good regrowth of grass prior to breeding time, the six flushing treatments increased lambing rates by an average of 6.5% more lambs born than the untreated control. The 1962 trial resulted in three of the flushing treatments exceeding the control and three resulting in fewer lambs born than the control. When the three years were averaged together there was little difference between the controls and treatment groups. One treatment which exceeded the controls (1 pound oats per ewe per day for 34 days) over the entire three year experiment produced only 5% more lambs than the controls. This benefit would not pay for the additional feed required. (AH b1-7)

2. Mating behavior.

a. Studies on behavior, semen production and fertility of sexually inhibited rams. Fifty-three purchased rams, 54 Sheep Station ram lambs and 2160 Sheep Station yearling and mature rams have been semen tested at the U. S. Sheep Experiment Station, Dubois, Idaho, during the past 8 years. Six percent of the purchased rams, and 13 percent of the Sheep Station ram lambs failed to copulate with nonestrual or estrual ewes under semen testing conditions compared with 32 percent of the Sheep Station yearling and mature rams. This indicates a problem exists in predicting probable fertility of a large number of rams due to inability to obtain naturally ejaculated semen samples for examination and to the poor predictive value of information obtained from electroejaculated samples. Such rams that fail to mate naturally have been referred to as "no work"rams.

One hundred and three "no work" rams were used in breeding from 1956 to 1960. The average lambing date of 1,378 ewes mated to 90 of the 103 "no work" rams was 1.4 days later than the average of an otherwise comparable group of 1,356 ewes mated to 90 normal rams. In addition, the remaining 13 of the 103 "no work" rams were either removed from breeding because of failure to breed (10) or had zero fertility (three).

The time required for "no work" rams to start working was studied in a group of 27 normal rams and 23 "no work" rams. All of the normal rams had copulated within 24 hours as compared to 35 percent of the "no work" rams. Seventy percent of the "no work" rams started mating activity within 48 hours, 79 percent within 72 hours, and 83 percent within 120 hours.

Another ram (four percent) worked after 14 days with the ewes. The remaining three rams (13 percent) were removed at eight or nine days for failure to breed.

The average fertility for the normal and "no work" rams was 93 and 76 percent, respectively. Selection of the normal rams on the basis of the naturally ejaculated semen sample accounts for a part of the difference in fertility between the two groups. Failure to breed or delay in breeding probably accounts for all or nearly all of the remaining difference.

There were no important differences in the quality of electroejaculated semen samples obtained from 97 normal and 43 "no work" rams. However, it was found that, though the above rams were used in breeding independent of semen quality evaluation, the semen quality traits of the normal rams were much more highly correlated with fertility than those of the "no work" rams (0.65 vs. 0.30, respectively).

The "no work" trait does not appear to be associated with inbreeding but does appear to be heritable. Once a "no work" ram begins working his libido appears to be entirely normal. (AH b1-7)

b. Breeding capacity of Targhee rams. Six pens of Targhee ewes (26 to 34 ewes per pen) at Dubois, Idaho, were synchronized for estrus with daily injections of 10 mg. of progesterone per day for 12 days. The ewes were put into breeding at the second post-treatment estrus and observed continuously for three days. One ram was used in each pen.

A large proportion of the ewes came into heat within the three-day period. In each pen the maximum number of matings occurred during the first 24 hours. The most active ram mated 48 times in the 24-hour period. The slowest ram mated 31 times. The average was 37 matings during the first 24 hours and 26 matings per 24 hours for the three days. The percent of ewes lambing to first service varied from 68 percent to 34 percent with an average of 48 percent. Eight percent to 38 percent of the ewes in the six pens were not observed in heat during the three-day observation period. The percent of ewes lambing to pen mating (35 days) ranged from 73 percent to 94 percent with an average of 87 percent. This percentage in the synchronized pens was slightly above the average (86%) for a comparable group of unsynchronized Targhee and Columbia ewes bred in pens of five ewes per ram. A higher proportion of the synchronized ewes lambed from the entire breeding season (which included range breeding after pen breeding for a total of 59 days) than of the unsynchronized ewes (93% vs. 87%). (AH b1-7)

3. Effects of the light environment on reproductive phenomena. Effects of variation in the light environment on ovulation rate, embryo survival and gonadotrophic content of the pituitaries of mature ewes during the breeding season are being studied at Dubois, Idaho, in cooperation with Utah State University. Except for hormone assay preliminary results from the first two years are now available.

The ewes were synchronized for estrus with intramuscular injections of progesterone in oil and subjected to continuous light, continuous dark or natural daylight (control) at about the time of the first estrus following synchronization. After 17 days half of the ewes in continuous dark were shifted to continuous light and half on continuous light were shifted to continuous dark. The ewes were slaughtered at approximately 3 and 25 days gestation in 1961 and 3 and 34 days gestation in 1962 to obtain ovulation and embryo survival rates. Continuous dark resulted in a consistently though not significantly higher ovulation rate (207%) than the control (197%). Light treatment had a marked effect on ova recovery rate. The recovery rate for the continuous dark group was consistently much poorer (ave. 65%) than the control (80%) or other treatments (82%). It is possible that ova degeneration accounts for this rather marked difference. Embryo survival rate was significantly affected by the light treatments. The continuous dark treatment had the lowest percent of normal embryo in relation to the number of copora lutea at 25 and 34 days of gestation in each of the two years (56%) as compared with 80% for the control, 71% for the continuous light and 84% for those groups switched from one light regime to another. No information is yet available on pituitary gonadotrophins. (AH b1-7)

4. Synchronization of estrus with orally active progestin. The effect of dosage (50 mg. vs. 60 mg.), length of treatment period (12 days vs. 14 days) and breeding at first or second post-treatment estrus on synchronization of estrus and lambing were compared at Dubois, Idaho. The hormone was incorporated into an all alfalfa pellet and fed to the ewes by groups.

The results indicate little difference in synchronization of estrus due to any of the treatments. Approximately 85% of all ewes came into heat within a four day period. However, 82 percent of the ewes mated for the first time at second post-treatment estrus lambed within a 12-day period compared to only 64 percent of those mated at the first post-treatment estrus. The latter percentage is very close to 61 percent fertility obtained a year ago under similar treatment conditions. It appears that synchronization is maintained very well until the second post-treatment estrus, and fertility is markedly improved by mating at this time compared to the first estrus following treatment. It is planned to repeat the experiment one more year. (AH b1-7)

5. Relationships of semen quality to fertility. Electroejaculation was compared with natural ejaculation for obtaining semen samples to predict ram fertility at Dubois, Idaho. The rams (140) were assigned independent of semen quality to breeding pens containing from 5 to 65 ewes. The data consisted of ram fertility as measured by percent ewes lambing of ewes present at lambing and semen traits (pH, volume, motility, concentration and morphology). When possible, two consecutive naturally ejaculated semen samples and two electrically ejaculated samples using two different ejaculators were obtained from each ram. Natural ejaculates were obtained from 94 rams and both natural and electroejaculates were obtained from 83 rams.

Electrically ejaculated samples were inferior in quality to naturally ejaculated samples. Correlations between semen quality traits and fertility were lower for all traits except pH and concentration when electroejaculated samples were compared with naturally ejaculated samples from the same rams. Correlations that were significantly different ($P>.05$) from each other involved morphological traits.

Information from the second of the two natural ejaculates was slightly more effective in predicting ram fertility than the same information from the first sample ($R = 0.74$ vs. $R = 0.69$). The predictive value of the second sample was also slightly superior to the mean of the first and second samples obtained naturally. Selecting the better of the two naturally ejaculated samples did not improve fertility prediction over routinely selecting second ejaculates. Retesting rams with initial low-quality samples did not improve fertility prediction.

It is concluded that natural ejaculates should be employed where possible or practical when attempting to predict fertility. Electroejaculation should be limited to use as a supplement or alternate to natural ejaculation when it is either impossible or impractical to obtain the natural ejaculate. The selection of the second natural ejaculate of each ram is the most efficient method of sampling a ram's semen for the purpose of predicting fertility of those studied.

Semen quality and ram fertility were studied in relation to the fecundity of ewes as measured by the percent of lambs born to ewes that lambed at Dubois, Idaho. The multiple correlation between six semen traits of the ram (motility score, percent motility, percent live normal cells, percent abnormal cells, percent abnormal necks and percent abnormal middlepieces) and fecundity of his mates was 0.49. The correlation between ram fertility (percent of ewes lambing of those present at lambing) and fecundity was 0.62.

Thus it appears that the fecundity of the ewe may be affected by the relative fertility of the ram in that the more highly fertile rams may fertilize a higher proportion of eggs ovulated by ewes than rams of lower fertility. (AH b1-7)

6. Fetal electrocardiography in the ewe. Preliminary studies were made at Beltsville, Maryland, of electrocardiography in the pregnant ewe to determine if pregnancy could be accurately diagnosed with this method. Such a method would not only indicate pregnancy but might also be used to detect number of offspring in multiple births. Practical methods of early pregnancy diagnosis in sheep are not available except by laparotomy. Such diagnosis would be of considerable advantage in management particularly under intensive production of more than one lamb crop per year. Preliminary results were inconclusive and indicated difficulties in making clearcut determinations. (AH b1-17)

B. Environmental Physiology

1. Effect of location on productivity of Targhee sheep. Production data on Targhee sheep are being collected in Hawaii; at Dubois and Moscow, Idaho; Fort Wingate, New Mexico; Spooner, Wisconsin; and Beltsville, Maryland.

Targhee rams were used in a topcrossing experiment to test their value for improving lamb production in Hawaii. In 1960 Targhee rams were mated to a sample of commercial ewes and the topcross offspring were compared with a control group of commercial lambs out of comparable ewes. Records at weaning (142 days) were available on 104 Targhee topcross lambs and 153 control lambs. All records were adjusted for the effects of sex and age of lamb and type of birth and rearing. The Targhee topcross lambs were 4.1 pounds heavier, had a slightly better score for mutton type, had a 9 mm. longer staple, and had a slightly coarser fleece than the control lambs. Only the difference in weaning weight was statistically significant ($P<.05$). These results indicate that Targhee rams could be used to improve weaning weights of lambs in Hawaii with little or no change expected in type score, staple length, and wool grade. (AH b3-4)

C. Physiology of Wool and Fiber

1. Development of mohair follicles in the skin of Angora goats. Analyses of histological preparations of biopsy samples of the skin of Angora goats are being continued at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station, McGregor, Texas. Current investigations will help to establish the range of medullated fibers per group of follicles. Information obtained earlier regarding medullated fibers was substantiated and it was again noted that this type of fiber is always present in the central primary follicles and in some of the lateral primary follicles. The diameters of the larger bulbs of Angora goat follicles measured 0.125 to 0.175 mm, while the dermal papillae observed in skin sections obtained during the summer period reached a length of 0.1 mm. (AH b5-1)

2. Sebaceous glands in sheep and goats. The sebaceous glands of sheep and goats function continuously from their inception at approximately 90 days of fetal life through maturity and old age. The glands associated with the primary follicles range in length from 0.250 to 0.375 mm in samples of Merino and Hampshire sheep; 0.350 to 0.450 in samples of Rambouillet rams as well as in the Texas Angora goats examined; and 0.250 to 0.315 mm in Toggenburg does.

Lecithin, or a closely related lipin, was found in the fat of the hypodermal and subcutaneous regions of the skin but was not evident in the sebaceous glands. Sebum was always present in all of the sebaceous glands. (AH b5-1)

3. Effect of season on mohair follicles. The incidence of medullated fibers differ in winter and summer samples taken from Angora goats at McGregor, Texas, and studied at Beltsville, Maryland. Counts of primary follicles made thus far indicate that more of the fibers in these particular samples, as observed within the skin are medullated in summer as compared with winter. There was a tendency for primary follicles to grow during the warm season and to rest during the winter. The secondary follicles of the Angora goat do not show a seasonal pattern of shedding and they resemble fine wool of sheep in that they lack medullation. For example, and this is irrespective of the time of year, a group consisting of 20 to 30 secondary follicles may show from 0 to 5 follicles in different stages of renewal. (AH b5-5)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Hulet, C. V., Blackwell, R. L., Ercanbrack, S. K., Price, D. A., and Humphrey, R. D. 1962. Effects of feed and length of flushing period on lamb production in range ewes. J. Anim. Sci. 21(3), pp. 505-510 (AH b1-7).

Hulet, C. V., Blackwell, R. L., Ercanbrack, S. K., Price, D. A. and Wilson, L. O. 1962. Mating behavior of the ewe. J. Anim. Sci. 21(4), pp. 870-874 (AH b1-7).

Hulet, C. V. and Ercanbrack, S. K. 1962. A fertility index for rams. J. Anim. Sci. 21(3), pp. 489-493 (AH b1-7).

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Hulet, C. V. and Foote, W. C. 1962. Observations in the ewe on the effect of ovum age on percent recovery and recovery site, and age of embryo on crown rump length. J. Anim. Sci. 21(3), p. 660. (Abstract) (AH b1-7).

Environmental Physiology

Cobb, E. H. and Morita, K. 1962. Use of Targhee rams for topcrossing in Hawaii. J. Anim. Sci. 21(3), p. 663 (Abstract) (AH b3-4).

Physiology of Wool and Fiber

Margolena, L. A., 1962. Sudoriferous glands of sheep and goats. Zeitschrift fur mikroskopisch-anatomische Forschung, 69(2), pp.217-225 (AH b5-1).

Margolena, L. A. 1963. Ziehl-Neelsen's stain for skin sections to show wool and hair follicles. Stain Technology 38(3), pp. 145-148 (AH b5-1).

SHEEP AND GOATS - NUTRITION AND MANAGEMENT
Animal Husbandry Research Division, ARS

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Division of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, New York, Oklahoma, Texas, and Utah. Studies on ruminant bloat contribute to the North Central regional project on the chemistry and physiology of bloat.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.2 to range and pasture management, 0.4 to management practices, equipment and facilities, and 0.4 to program leadership.

A grant involving Public Law 480 funds is in progress at the Ankara University, Ankara, Turkey, and is related to the methods of feeding and management on white muscle disease in lambs. The program is supported for 3 years (1963-1965) by $9333, equivalent in Turkish lire.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Metabolic disorders. Basic and applied studies into the causes and prevention of urinary calculi were continued at College Station and Big Spring, Texas, with both steers and wethers. Two years' work of a three year study to compare the reactions of the steer and wether to factors involved in calculi formation at Big Spring indicates that different mineral ratios or mechanisms may be involved in calculi formation in the steer and wether; however, ammonium chloride seems to offer an effective means of control in both species.

Studies at College Station with wether lambs were designed to test the effect of pelleting, the size of the pellet, and the addition of sodium or potassium chloride to the diet. Pooled results of two years' work showed that 38 percent of the lambs fed the basal diet developed stones compared with 56 percent of the lambs fed pellets. The addition of one percent sodium chloride to the basal diet decreased the incidence from 38 to 25 percent. Sixty percent of the lambs affected were lost. The incidence was reduced to 10 percent with no clinical cases when 1 percent potassium chloride was used in place of the sodium chloride. (AH b2-1)

2. Feeding practices and procedures. Studies over a 5-year period at Beltsville, Maryland, have indicated that animals receiving alfalfa hay pellets ad libitum over a period of time become obese and have a shorter life span than normally fed animals. At autopsy in extremis or shortly after death, two common findings have been (1) an inflamation of the proximal duodenal mucosa and (2) a liver pathology, referred to, probably incorrectly, as chirrosis. To further study the pathology resulting from long-term pellet feeding or from resulting obesity, 11 animals ranging in age from 1 to 3 years were slaughtered and posted. One animal displayed the characteristic liver pathology and two had pneumonia. No gross pathology was observed in the remaining animals. Eight animals that had received chopped hay ad libitum for similar periods also were slaughtered and posted-none displayed any pathology. An experiment is now being designed to: (1) compare the life span of sheep fed alfalfa hay pellets ad libitum and at a low level of intake adequate to maintain normal growth and condition; (2) to distinguish between the effect of pellet consumption and the resultant degree of obesity on the life span; (3) to characterize any pathology resulting from alfalfa hay pellet feeding; and (4) to distinguish between the effect of pelleting alfalfa hay per se and the degree of obesity or any resultant pathology.

Two experiments were conducted at Beltsville to determine the effect of pelleting alfalfa hay on the ad libitum consumption of salt and of water by sheep. In the first experiment the effect of the physical state of the hay (ground vs. pelleted) on salt consumption was studied. Where salt was allowed free choice, salt and water consumption was greater on the pelleted

than on the ground hay diet. Where salt consumption was restricted, to normal intakes, the physical form of the hay had no effect on water intake. The second experiment was designed to determine the effect of level of feed intake on ad libitum salt and water consumption. Free choice salt consumption decreased as hay pellet intake increased but water intake increased as the pellet intake increased. It would, therefore, appear that level of intake, which, under practical feeding conditions, is greater when pelleted forages are fed, is probably a greater stimulus to increased water consumption than any increase in salt consumption that may accompany the feeding of pelleted forage.

Trials over an 18 month period at Beltsville to compare the wool production of sheep fed pelleted alfalfa with that of sheep fed chopped alfalfa have been completed. Preliminary results indicate that wool production is similar when equal amounts of pellets and chopped hay are consumed. (AH b2-5)

The response of 965 Rambouillet, Targhee and Columbia ewe lambs subjected to three methods of feeding, using two qualities of alfalfa hay, was investigated during 1961 and 1962 at Dubois, Idaho. The five winter feedlot treatments (112 day period) were: (1) high quality baled alfalfa hay fed on the ground at a rate of 4.5 pounds per head, per day; (2) self-fed high quality chopped-hay pellets (average daily consumption 5.7 pounds); (3) self-fed low-quality chopped-hay pellets (average daily consumption 5.6 pounds); (4) hand-fed high-quality chopped hay pellets at a rate of 3.4 pounds per head, per day; and (5) hand-fed low-quality chopped-hay pellets at a rate of 3.4 pounds per head, per day. The pellets were fed in troughs or self-feeders. The average daily gain per head, per day, was 0.18 pound for the baled hay group; 0.58 pound for the self-fed high quality hay pellets group; 0.55 pound for the self-fed low quality hay pellet group; 0.31 pound for the hand-fed high quality hay pellet group; and 0.27 pound for the hand-fed low quality hay pellet group. Grease fleece value was significantly higher for the self-fed pellet groups than for the other groups and was slightly higher for the hand-fed pellet groups than for the baled hay group.

The relative merit of feeding a 100 percent ground alfalfa hay pellet compared with various rations of barley and alfalfa for the fattening of feeder lambs for slaughter was investigated at Dubois, Idaho. The lambs were about 60 days of age upon entering the feedlot and the rations were self-fed for 42 days. Lambs fed the 100 percent ground alfalfa hay pellet had the lowest feed cost per pound of gain but the highest shrinkage in body weight in transit to market at Ogden, Utah. The net return per lamb was $2.00 for those receiving 100 percent alfalfa hay pellets, $2.14 for those receiving a 50-50 ratio of alfalfa to barley, and $2.27 for those receiving a 25-75 barley-alfalfa-pellet.

Winter feeding trials were conducted with 540 ewes at Dubois, Idaho, in an attempt to find a more economical and time saving method of feeding pregnant ewes in the winter feed lots. Lot 1 was fed 5.8 pounds of baled hay on the

ground, lot 2 was fed alfalfa pellets according to National Research Council recommendations, lot 3 was fed pellets at 95 percent of the NRC recommendations, and lot 4 at 90 percent of the NRC recommendations. Method of feeding and amount of feed had no apparent influence on body weight gains, percent of live lambs born or on birth weight of the lambs. Butterfat determinations on samples of milk from 44 lactating ewes from the various groups did not indicate any depression in butterfat content due to the feeding of pellets.

3. Studies on nutritive requirements of sheep. The potassium requirement of the growing lamb was investigated in cooperation with the Division of Nutrition, Food and Drug Administration at Beltsville, Maryland. Two lambs, a ram and a ewe, weighing about 50 pounds, were fed 0.0, 0.3, 0.6 or 0.9 percent potassium as potassium acetate as a supplement to a synthetic diet containing casein, sucrose, hydrogenated vegetable oil, celluflour, a salt mixture, and vitamins A, D, E, and the major members of the B complex. The diets and tap water were offered free choice. After 7 weeks, there was a weight loss at all levels of potassium supplementation of 7 to 12 pounds per lamb. Because there was no graded response in weight change over the levels of potassium supplementation, it was concluded that the poor response was due to nutritional inadequacies other than potassium level. One lamb died during this period and a second was sacrificed *in extremis.* No gross pathological lesions attributable to potassium inadequacy were observed; histopathological determinations have not been completed. In the ensuing three weeks, the sucrose of the basal diet was replaced with equal parts of cornstarch and glucose monohydrate and solka-flock replaced the celluflour. Gains per lamb in the 0.6 and 0.9 percent potassium groups ranged from four to nine pounds over this period while there were losses of from one to five pounds per lamb in the 0.0 and 0.3 percent potassium groups. The experiment was terminated by necropsy of the remaining lambs. There was no gross pathology apparent at any level of K supplementation. Histopathological determinations on the tissues have not been completed. (AH b2-5)

An experiment was conducted in 1963 at Dubois with 140 ewes and their 200 suckling lambs to determine the effect of different methods of feeding ewes after lambing as measured by body weight of lambs as they left the mixing pens to go on the range at an average age of 32 days. The effects of sex, type of birth and rearing, age of dam, birth weight, and age in days were held constant. The ewes were fed in one group prior to lambing. After lambing they were divided into four treatment groups and fed as follows: lot 1, alfalfa hay plus 2 pounds of oats; lot 2, alfalfa pellets plus 2 pounds of oats; lot 3, alfalfa hay, no grain; and lot 4, alfalfa pellets, no grain. The average body weight of the lambs weighed out of the mixing pen was 27.7 pounds. Lots 1, 2, and 3 were 3.0, 1.4, and 0.9 pounds heavier than lot 4 in body weight indicating in this trial an advantage for feeding grain after lambing. The weaning weights of these lambs will be compared as the information becomes available. (AH b3-9)

The effect of sex and initial weight on the gain and feed efficiency of fattening feeder lambs receiving a high concentrate and a standard fattening diet was studied at El Reno, Oklahoma. The high concentrate diet contained approximately 83 percent concentrates and the normal diet, 50 percent. The base grain was milo. Wether lambs in each weight group fed the high concentrate diet gained more rapidly and required less feed per hundred weight than the lambs on the standard diet. Ewe lambs varied in their response to the diets. The heaviest ewe lambs fed the high concentrate diet gained more rapidly on less feed, but the reverse was true with the light lambs. Within weight groups and diet groups, wether lambs did not consistently gain more rapidly than ewe lambs; however, in three cases out of four, they required less feed per hundred pounds of gain. Considering gain based on body weight, there was little difference in average daily gain of the three weight groups. The heavier lambs gained considerably faster, but the difference was due mostly to greater body size. (AH b3-7)

B. Forage Evaluation and Utilization

1. Forage intake by range sheep. Quantity and quality of the nutrient intake of sheep grazing on the U. S. Sheep Experiment Station, Dubois, Idaho, fall, winter, spring, and summer ranges are being investigated by the use of esophageal fistulated sheep to obtain dietary intake and bagged sheep for total feces collection. Digestion trials were conducted at early, intermediate and late periods of the summer season on the mountain summer range. Samples obtained from these trials are under laboratory analyses. Preliminary results of the chemical analyses of the esophageal fistula samples indicated that the crude protein content declined from 16.95 percent to 14.13 percent from period one to period three and that the crude fiber content increased from 18.53 percent to 19.36 percent during the same period. Forage samples also have been collected on the spring, fall and winter ranges using esophageal fistulated sheep and are being subjected to laboratory analyses. (AH b3-9)

C. Range and Pasture Management

1. Grazing practices. Studies on the effects of grazing sheep and cattle together have been continued at Beltsville. The design of this experiment has been described in previous reports - the only difference is that the ladino clover has died out leaving an almost pure stand of orchard grass. The trial was started on April 11 of this season. Through July 3 (83 days) sheep grazing alone averaged 0.35 pounds per day which was significantly less than for sheep grazing with cattle, 0.39 pounds, per day. Stocking rate had no significant effect on sheep gains and the average gain of the sheep grazing with cattle at the 1:1 ratio was not significantly different from those grazing at the 1:5 ratio. Preliminary investigations have not indicated that the helminth level of the sheep grazed alone is different from those grazed with cattle. The animal phases of digestibility and organic matter intake studies have just been completed; however, the analytical work has not been completed. (AH b3-10)

2. Management in relationship to parasitism. Studies on the effects of management practices in relationship to parasitism and gains of lambs have been continued at Beltsville in cooperation Animal Disease and Parasitism Division. Four management systems have been studied in 1963. These include, (1) early weaning of lambs (about 60 days of age and the lambs grazed on clean pastures from the start of the experiment; (2) lambs separated from the ewes at 8:00 a.m. and grazed separately in clean pastures until 4:00 p.m. and then allowed to nurse the ewes in drylot overnight; (3) ewes and lambs grazed on contaminated pastures, plus therapeutic treatment with N. F. phenothiazine when indicated by fecal egg counts; (4) ewes and lambs grazed on contaminated pastures, plus therapeutic treatment with thiabendazole when indicated by fecal egg counts. Lambs in bands II, III, and IV were weaned at 120 days of age. Average daily gain of the lambs from April 10 through June 19 (when all lambs were weaned) was 0.49 pounds for the early weaned lambs, 0.37 pounds for the lambsgrazed separately from their dams, and 0.43 and 0.40 for the two groups grazed on contaminated pastures. Fecal egg counts on July 3 revealed that the early weaned lambs had three haemonchus eggs per gram, the lambs grazed separately from their dams had 16, while those grazing on contaminated pastures had 1038 and 865 eggs per gram, respectively, for bands III and IV. (AH b3-11)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Lindahl, I. L., Kates, K. C., Turner, J. H., Enzie, F. D. and Whitmore, G.E. 1963. Effect of management systems on the growth of lambs and development of internal parasitism. I. Dry lot vs. two pasture rotation systems. The Journal of Parasitology 49(2), pp. 209-217 (AH b3-11).

INFECTIOUS AND NON-INFECTIOUS DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. There are at least 18 infectious diseases of sheep and goats in the United States that cause an estimated annual loss of 15 million dollars. Non-infectious diseases are estimated to cause an additional 3 million dollar loss annually. The cause of some of these diseases is known; others have more than one causative agent contributing to produce the effects seen in field cases. Environmental, genetic, and unknown factors appear to play a part in some diseases. The natural reservoirs of the known infectious agents have not been fully determined. Fundamental information on methods of transmission and means of prevention are needed for many of these diseases. Vaccines and other immunizing products are available for some diseases of sheep but not for others. Some of these products might be improved. Prevention, control, or eradication of disease is necessary for economic and efficient sheep and goat raising. Due to lack of accurate, rapid diagnostic techniques, infectious diseases often get a substantial start in a band or flock before they are recognized, partly because they are easily confused with non-infectious diseases.

USDA PROGRAM

The Department has a continuous long-term program involving biochemists, microbiologists, pathologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of infectious and non-infectious diseases of sheep and goats. Research is being conducted on the diseases at the following designated locations.

The Federal scientific effort devoted to research in this area totals 7.6 professional man-years. This effort is applied as follows:

Bluetongue, 2.0 at the Denver Animal Research Laboratory, Denver, Colorado.

Contagious Ecthyma, 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Foot Rot, 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Vibriosis, 0.3 under cooperative agreements with the Colorado, Montana, and Utah Agricultural Experiment Stations.

Scrapie, 0.2 at the Agricultural Research Council Field Station, Compton, Berkshire, England, and the Moredun Institute, Edinburgh, Scotland, through two grants of PL 480 funds, equivalent to $300,165. The work is coordinated through the European Mission for Research on Animal Diseases, Amsterdam, Holland.

Viral Ulcerative Dermatosis, 0.1 through a cooperative agreement with the Colorado Agricultural Experiment Station.

Paratuberculosis or Johne's Disease, 1.0 at the National Animal Disease Laboratory, Ames, Iowa.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Bluetongue.

During the reporting period, July 1, 1962 to June 30, 1963, at the ADP Denver Laboratory, sheep blood samples were tested representing suspected bluetongue (BT) outbreaks in 24 bands and flocks from 8 States, all of which were found to be infected. Cattle blood samples of 15 herds from 5 States were tested for BT virus and found positive.

Thirty one lambs and 12 adult ewes were infected with BT virus either by intravenous, subcutaneous, or intradermal inoculation. The intradermal route was the route of choice for infecting sheep since it is analogous to the route by insect bites and only relatively small dosages were required to elicit a typical BT clinical response. The characteristic clinical responses of the BT infected sheep in their usual chronological sequence were panting; hyperemia of the skin of the muzzle, lips, and ears; elevated body temperature; inflammation, swelling, and ulceration of the oral mucous membranes; anorexia; depression; aspiration pneumonia; coronitis and death. The onset of these signs and symptoms occurred on day after inoculation (DAI) 1-7 and commonly terminated by DAI 14 in the lambs and by DAI 21 in the adult sheep. Emphasis was placed on the correlation of hemogram changes with the clinical manifestations and necropsy observations. A leukopenia developed in all of the infected sheep. In young sheep the average maximum leukopenia occurred 48 hours prior to the average peak body temperature, while in adult sheep they both occurred on DAI 7. Also, lambs had their average peak body temperature on DAI 7. A neutropenia, eosinopenia, and lymphopenia occurred in 86% and a hemolytic anemia was observed in all but one of the experimental sheep. The neutropenia and eosinopenia developed during the convalescing stages of the infection, while the lymphenia paralleled the leukopenia.

Work was continued at the Denver Laboratory, in cooperation with the Entomology Research Division, in studies on the role of insects as transmitters of virus diseases. The results obtained from a series of 5 experiments indicate that the sheep ked, Melophagus ovinus (L.) can transmit the virus of bluetongue disease in sheep. Ten of the 18 principal BT susceptible sheep used in the experiments on which sheep keds were manually transferred from a BT host virus sheep, were positive, 6 questionable, and 2 negative for clinical evidence of BT disease. Five of the above 10 positive sheep had mild infections. Fifty percent of the questionable reacting sheep and 60% of the mildly reacting sheep had highly intensified clinical BT reactions when challenged with the standard BT virus. Five of the 10 positive reacting sheep were immune following their challenge with known BT virus. Blood

obtained from 2 of the positive reactors was subpassaged into BT susceptible sheep and they reacted with typical signs and symptoms of the disease.

A procedure has been developed at the Denver Research Laboratory for counting sheep leukocytes and erythrocytes by electronic means. A device and technique has also been developed for handling quantities of coverslips used in fluorescent antibody and other cell culture work. A technique and apparatus were designed for collecting large quantities of sterile blood quickly without hemolysis. (Denver, Colorado)

Using the bluetongue virus as a tool for virus study at the Fur Animal Disease Laboratory, Pullman, Washington, it was found that the relationship of mouse age to virus susceptibility was influenced by the passage level of virus used. Virus of the 7th passage produced mortality in one, but not in two-week-old mice, whereas virus representing the 53rd passage killed 5-month old mice. Peak titers were recorded at approximately the same time in the different age groups, but were inversely related to mouse age. A marked prolongation of survival times was observed in 3- to 20-week-old mice as compared to one-week-old mice.

Analysis of graded response data showed the distribution of survival times for suckling mice to be approximately normal, but for mice one and one-half to 3 months of age the same distribution was positively skew with 20 per cent of the animals demonstrating increased resistance. The two distributions had equal standard deviations.

A study of virus multiplication in one and one-half to 3-month-old mice revealed an earlier reduction of infectivity in brains of surviving mice than in mice that succumbed to the infection. Late spread of virus to important neural sites or increased sensitivity to the virus are possible explanations for deaths following markedly prolonged survival times. The pattern of virus multiplication in older mice disagrees with the concept of the incubation period as a time of steady virus multiplication in infected organs.

The interfering effect of high doses of active egg-propagated bluetongue virus upon mouse-adapted virus resulted in no reduction in mortality but markedly prolonged survival times. The failure of absolute interference most likely was due to a dual infection with immunologically related viruses in the same cells. The results indicate that the site of interference is one of the late steps (virus synthesis or release) in the multiplication cycle. (Pullman, Washington) (ADP a3-5)

B. Vibriosis in Sheep.

In work under a cooperative agreement with the Colorado State University at Fort Collins, two year-old primigravid ewes were used to determine the efficacy of killed Vibrio fetus serotypes I and V organisms to protect sheep against measured dosage of (a) serotype I culture challenge, (b) serotype V culture challenge, and (c) serotype I and serotype V (1:1 ratio) culture

challenge. Immunity was challenged during advanced gestation. One abortion occurred in 21 ewes vaccinated with serotype I and serotype V organisms when challenged with serotype I organisms. No abortions occurred in 40 ewes similarly vaccinated when challenged with serotype V organisms, or the combined serotype I and V challenge inocula. Fifteen abortions (65.2%) occurred in 23 nonvaccinated, serotype I challenged control ewes, while four abortions (19.0%) occurred in 21 nonvaccinated serotype V challenged control ewes. (Fort Collins, Colorado)

In cooperation with the Montana Veterinary Research Laboratory of the Montana Agricultural Experiment Station at Bozeman, work has continued on serotype change. A total of 91 ewes were on an experiment conducted in the Spring of 1963 to obtain data on the possibility of serotype changes. Forty-two cultures of V. fetus were isolated from aborted fetuses and used to make antigens. Serotyping has not been completed. Studies were made on the significance of intestinal infection with Vibrio fetus.

Cultures of V. fetus intestinalis were obtained from Belgium and studied. Initial attempts to isolate V. fetus from previously inoculated ewes were not successful. Better results were obtained later using brilliant green-blood agar. A total of 12 isolations of vibrios, 10 of which were V. fetus, were made from 4 ewes during a period of 11 days following rumen injection.

The significance of placental infection with V. fetus was studied in normally lambing ewes. A total of 176 placentas from a ranch with a previous history of vibriosis (1960, 1962) were obtained for culture and two isolations of V. fetus were made. Insofar as could be determined, both isolations were made from the placentas of normal lambs. It would appear that vibriosis has been maintained on the ranch since 1960, although the flock appeared to lamb normally in 1961 and 1963.

Additional work was done on the identification and propagation of V. fetus. Temperature tolerance at 25°C, 37°C, and 42°C was determined for a number of V. fetus cultures of various origins. This procedure has some promise for identification. A simple method for the production of heavy growth of bovine and ovine V. fetus cells was developed. (Bozeman, Montana)

In cooperation with the Utah State University, Utah Agricultural Experiment Station, at Logan, the work was continued on studies on vaccination. The replacement ewes of two bands with a total of about 2,000 ewes each, were vaccinated for the third year with a vibrio vaccine. One band had an abortion rate of 2.1 per cent and the other 3.5 per cent. No vibrio organisms were isolated from these abortions. Vaccination of the replacement ewes appears effective in eliminating Vibrio fetus infection of a given band or flock.

The effect of vibrio organisms classified as Vibrio fetus and Vibrio bubulus differing distinctly in their cellular morphology, catalese activity and hydrogen sulfide production, was studied during the first 24 hours after

intravenous inoculation of pregnant and nonpregnant ewes. All strains studied caused a rapid drop of the total leukocyte number. The lowest point was reached 3-5 hours after inoculation. The number of leukocytes increased then again and was slightly above the pre-inoculation values at the 24th hour. The vibrio organisms inoculated were removed from the blood within 30-60 minutes except when coccoid Vibrio fetus organisms were used which remained in blood up to 6 hours. Two of the ewes inoculated with the coccoid organisms died 6 and 9 hours thereafter. The vibrio organisms were eliminated from most of the organs of the ewes after 24 hours. Vibrio organisms were isolated at that time in low numbers and irregularly from brain, meninges, pancreas, skeletal muscle and duodenum. They were detected rather regularly from the gall bladder tissue and were there in numbers as high as 10^6 per Gr. of tissue. All Vibrio fetus strains were found in the uterus and uterine content at the time of necropsy 24 hours after inoculation. (Logan, Utah) (ADP a3-1(R)

C. Scrapie

Investigations of scrapie in sheep and goats has continued under the terms of the agreement at the Agricultural Research Council Field Station, Compton, Berkshire, England. An encephalopathy has been produced in mice by intracerebral inoculation of material taken from goats infected with scrapie. Pathology in the mice is similar to that in goats and sheep. The incubation period in mice is 7 months. Research with mice is continuing and it is possible that in time mice may replace goats as experimental animals in scrapie research. However, a considerable amount of additional work is necessary before a decision of this nature may be reached.

In attempts to demonstrate specific antibodies to the scrapie agent the workers have tried to hyperimmunize infected goats and rabbits with suspensions of infected brain material. All attempts to demonstrate complement fixation and virus neutralizing antibodies have failed. Attempts have also been made to transmit the disease to goats by oral doses of scrapie saliva or feces from animals infected with scrapie. From these studies it would appear that it is difficult to transmit experimental scrapie by contact among housed animals and that the agent seems unlikely to be present in saliva or feces.

It has also been found that the agent of scrapie is extremely resistant to formalin. Ten per cent suspensions of scrapie goat brain material were adjusted to contain .01, .05, 1%, 2%, 4% or 8% formalin in normal saline. After thorough shaking these suspensions were incubated for 18 hours at 37°. All inoculated animals developed the disease. There was no significant variation in incubation time between groups of goats that were infected which would indicate that formalin treatment, even in 8% concentration, had not affected the scrapie agent adversely.

More recently it has been shown that the 5th tissue culture passage material may contain a scrapie agent. One mouse inoculated with the tissue culture material died approximately 8½ months after inoculation. Thus far there has

been no evidence of the spread of the disease by contact between mice inoculated with the scrapie agent and those not so inoculated over a 168 day period of observation. Work is continuing along the lines mentioned above.

At the Moredun Institute, Edinburgh, Scotland, work has also continued under the terms of the agreement. Particular emphasis has been placed on the genetic constitution that probably determines susceptibility. The main feature is the continuing high incidence of scrapie in certain groups or blocks. These groups include those where dams and sires are from scrapie parentage (SS) or dams are from scrapie parentage and sires are from scrapie-free parentage (SF). These are compared to groups where dams and sires are from scrapie-free parentage (FF) or dams are from scrapie-free parentage and sires are from scrapie parentage (FS). (ADP a3-3)

D. Viral Ulcerative Dermatosis.

In cooperation with the Colorado Experiment Station, in vivo immunologic studies indicated that sheep immune to ulcerative dermatosis (UD) remained susceptible to contagious ecthyma (CE) and vice versa. Convalescent serums produced by either agent did not provide measurable protection when incubated with the homologous viral agent and inoculated onto susceptible sheep. Unequivocal antibody formation could not be detected in the immune serums against either UD or CE by the in vitro technique employed. The failure to positively demonstrate antibodies in the convalescent serum of sheep in this investigation precluded any possibility of studying the immunologic relationship of these two viral agents by the serologic tests employed.

The viruses of ulcerative dermatosis (UD) and contagious ecthyma (CE) were adapted to growth in monolayer cultures of bovine embryonic kidney cells. After ten culture passages, there was no demonstrable reduction in the pathogenicity of the viruses for sheep. Mice, rabbits, guinea pigs, and hamsters were refractory to scarification and inoculation with the agents of UD and CE. Both virus entities were resistant to ether.

The question of the similarity of the agents of UD and CE is not clearly defined, and there may be more agents of the ovine dermatitides complex that need investigation and comparison. The multiplicity of strains has not been adequately investigated and undoubtedly plays a major role in the various dermal infections of sheep. (Fort Collins, Colorado) (ADP a3-4)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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FOOT-AND-MOUTH AND OTHER EXOTIC DISEASES OF SHEEP
Animal Disease and Parasite Research Division, ARS

Problem. For the early detection of any outbreak of foot-and-mouth disease, comprehensive information regarding its effect on all susceptible species is necessary. The effect of foot-and-mouth disease (FMD) on cattle and swine has been, and is being investigated, however, little information is available pertaining to the disease in sheep. Sheep infected with FMD could serve as a source of infection and initiate the spread of the disease. Although primary research emphasis on exotic diseases of sheep at the Plum Island Animal Disease Laboratory is on FMD because of its great economic importance, other exotic diseases of sheep, such as rinderpest, sheep pox, louping ill, Nairobi sheep disease, and Rift Valley fever, are of concern to the Plum Island Laboratory because techniques and materials may be needed for diagnosis, control, and eradication on short notice and unexpectedly. Such diseases, if introduced into this country, could result in high death tolls or cause serious economic losses among susceptible sheep and other livestock. The problem is one of development of basic information applicable to protection of the nation's sheep from foreing animal diseases; development and maintenance of competence in diagnosis of these diseases, and fundamental research on the biological, chemical, and physical properties of the infectious agents that may be useful in prevention, control, and eradication of these diseases.

USDA PROGRAM

The Department has recently activated a continuing and long-term program involving veterinarians, biochemists, microbiologists, and pathologists, engaged in basic and applied research in some of the problems in this area.

The Federal scientific effort devoted to research in this area totals 2 professional man years. This effort is divided among sub-headings as follows:

Foot-and-Mouth Disease of Sheep,1.0 at the Plum Island Animal Disease Laboratory, Greenport, Long Island, New York.

Rinderpest in Sheep, 1.0 at the Plum Island Animal Disease Laboratory, Greenport, Long Island, New York.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Foot-and-Mouth Disease in Sheep

At the Plum Island Animal Disease Laboratory, the clinical and serological responses of sheep after infection with foot-and-mouth disease virus (FMDV) are being determined. Sheep were shown to be susceptible to infection with FMDV by inoculation and by contact exposure. The disease in sheep was characterized by fever and the development of vesicular lesions involving the oral mucosa and coronary borders of the feet. Infected near-term ewes did

not abort. Hematological changes were those associated with infections characterized by neutrophilia; there was no evidence of leukopenia.

Virus-neutralizing, complement-fixing, and precipitating antibodies were detected in the serums of sheep following infection with FMDV. Investigations have been and are being conducted on the persistence of these antibodies. Virus-neutralizing antibodies were still present 462 days post-inoculation; precipitating antibodies 378 days post-inoculation. The persistence of antibodies in sheep following infection with FMDV and the fact that these antibodies may be readily detected is significant from a regulatory standpoint. A lamb testis cell line developed at PIADL was used in micro-cinematographic study of cellular reactions to infection with FMDV. This lamb testis cell line was also used in the development of fluorescent antibody technique to locate FMDV in the cell.

A film was prepared at PIADL on the Cytopathic Effect of FMDV in Lamb Testicular Cells.

B. Rinderpest in Sheep

At the Plum Island Laboratory work has been instigated to determine the effects of a bovine strain of rinderpest virus on sheep raised in the United States. Sheep are not highly susceptible to rinderpest virus, hence detection of exposed animals is difficult. Studies with experimentally infected sheep have shown that rinderpest virus may be recovered from the blood for 10 days after inoculation. Tests in cattle with blood taken during this period would be of value in diagnosis.

Sheep did not show clinical signs of infection when inoculated with a tissue culture modified strain of rinderpest virus which was developed for use as an immunizing virus for cattle. The modified virus prompted production of rinderpest antibodies in sheep.

PUBLICATIONS REPORTING RESULTS OF USDA RESEARCH

Hess, W. R., H. J. May, and R. E. Patty. 1963. Serial Cultures of Lamb Testis Cells and Their Use in Virus Studies. Amer. J. Vet. Res., 24: Jan., 59-64.

PARASITES AND PARASITIC DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. The cost of parasitic diseases to the sheep and goat industry of the United States is estimated to be in excess of $45 million, annually. Disorders caused by parasites are ubiquitous, generally insidious and often overlooked entirely. Diagnosis is difficult, and successful treatments for many of these diseases are not available. Moreover, management practices to avoid spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling or eradicating parasitic diseases so as to provide for healthy animals, insure adequate supplies of high quality lamb for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

USDA PROGRAM

The Department has a continuous long-term program involving biochemists, parasitologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of parasites and parasitic diseases of sheep and goats. Research is being conducted on these diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 8.2 professional man-years. This effort is divided among sub-headings as follows:

Lungworms 1.0 at the Beltsville Parasitological Laboratory.

Bionomics of Coccidial Parasites 2.0 at the Beltsville Parasitological Laboratory.

Effects of Helminth Infections on Serum Proteins 0.5 at the Beltsville Parasitological Laboratory.

Gastrointestinal Nematodes 2.1 at the Beltsville Parasitological Laboratory, and under a cooperative agreement with the Kentucky Agricultural Experiment Station at Lexington.

Helminth and Protozoan Parasitism in the South 1.5 at the Regional Animal Disease Research Laboratory, Auburn, Alabama, and through informal cooperation with the Mississippi Agricultural Experiment Station, State College.

Biology, Pathogenesis, and Control of Helminth Parasites of Sheep in the Southwest 1.0 at the University Park, New Mexico, field station, and through informal cooperation with the New Mexico Agricultural Experiment Station at University Park.

Effect of Intestinal Roundworms on Metabolism 0.1 under cooperative agreement with the North Dakota Agricultural Experiment Station, Fargo.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Effects of Helminth Infections on Serum Proteins.

The serum proteins of three groups of 4 Shropshire lambs were analyzed by a paper electrophoresis technique to investigate differences which might result from parasitism or management practices, or both. Serums from lambs raised helminth-free had consistently higher albumin/globulin ratios (A/G) and lower gamma globulin percentages than did serums from lightly parasitized, barn-raised lambs.

Serums from 10-month-old barn-raised lambs had a gamma globulin average of 16 percent and an average A/G ratio of 2.2, whereas serums from naturally parasitized lambs on pasture had a gamma globulin average of 46 percent and an A/G ratio of 0.4. Total serum protein values were higher in barn-raised lambs than in either of the other two groups.

The A/G ratios and total serum protein values rose as the lambs matured, when significant parasitic infections were absent, but decreased with age in parasitized animals.

Inhibited development of Haemonchus contortus larvae apparently occurred in one lamb. This inhibited development may be related to the high gamma globulin percentage produced by previous exposure to this nematode. (Beltsville, Maryland) (ADP b3-15)

B. Gastrointestinal Nematodes.

Preliminary studies of the mechanism of control exerted by the immunological response of the sheep host on the developmental stages and fecundity of the intestinal thread-necked worm, Nematodirus spathiger, have been completed. The results of these studies show that control of the parasitic infection is centered about threshold levels of immunological responsiveness and is expressed by (1) elimination at the infective, or 3rd larval, stage, (2) retardation of development at the 4th larval stage, (3) reduction in egg production of the adult female, (4) elimination of adult worms, and (5) discrimination against the female in both the degree of retardation of the 4th larval stage and the extent of elimination in the adult stage. Information such as this is required to better understand the relationship between host and parasite in order that more effective control measures against ovine parasites can be devised. (Beltsville, Md.)

In cooperation with the University of Kentucky, in a comparative evaluation in lambs, a series of six monthly drenches of thiabendazole, ruelene, or phenothiazine during a summer grazing season doubled the rate of gain of body weight over that of a control group. At the close of the test the body

weights averaged 92.2 pounds for the thiabendazole-treated group, 95.3 pounds for the ruelene-treated group, 97.7 pounds for the phenothiazine-treated group, and 79.6 pounds for the untreated group. The relatively poor performance of the thiabendazole-treated group was due to the selection and build-up during the course of the study of a population of the common stomach worm that was not effectively controlled by the 50 mg/kg dose of thiabendazole. Two of the 10 lambs in the untreated group died of acute parasitism. One of the ruelene-treated group died of an undetermined cause. (Lexington, Kentucky) (ADP b3-16)

C. Helminth and Protozoan Parasitism in the South.

The life cycle of Eimeria ahsata in sheep has been worked out at the Regional Laboratory, Auburn, Alabama. The prepatent period varies from 18 to 21 days. Sporozoites were found in the intestinal mucosa at 2 and 5 days. Schizonts measuring 50 µ were found by the 10th day and the largest measuring 162 by 265 µ was seen on the 15th day. It is suggested that only one generation of schizonts and merozoites is produced. Gametogenesis was first seen at 11 days with oocysts located mostly in cells lining the intestinal glands. The endogenous stages were located throughout the small intestine with the greatest numbers in the jejunum. (Auburn, Alabama) (ADP b3-13:b3-19)

D. Biology, Pathogenesis, and Control of Helminth Parasites of Sheep in the Southwest.

Efforts were made to demonstrate functional immunity against haemonchosis in lambs under both field and laboratory conditions by inoculating them with a naturally attenuated strain of the parasite from pronghorn antelope and administering an anthelmintic 21 days later to remove the worms. A total of 39 worm-free lambs were used. As compared with untreated inoculated groups, lambs treated as described above showed no evidence of an immunity. Apparently removal of the infections by means of an anthelmintic 21 days after inoculation resulted in the loss of the immunizing effect. Further work with the attenuated strain as a possible immunizing agent is warranted.

Liver flukes were found to be economically important parasites in sheep in one additional area in New Mexico and in one area in Colorado. A total of 38 sheep from 3 different farms were examined and over 50 percent were infected. Fossaria modicella, a snail known to be a vector in other areas of the West, was found on two of the farms in question, but it remains to be determined whether this snail is involved in the transmission of flukes in New Mexico and southern Colorado.

Information as to the occurrence of lungworms in sheep was obtained from southern Colorado. Thirteen of 26 animals examined harbored the parasites. Information about this occurrence and about a case in New Mexico sheep was assembled and described in a report now in press. This constitutes the first record of lungworm in sheep in the two States concerned.

Controlled anthelmintic tests showed Hetol at a dose rate of 8.6 g/sheep to be 100 percent effective in removing adult common liver flukes from sheep, but ineffective against immature (half grown and under) flukes and against the liver tapeworm. Similar tests involving Bayer 2353 and Bayer ME3625 and sheep harboring the liver tapeworm demonstrated that the former compound in particular, when given at a dose rate of about 500 mg/kg, is sufficiently promising to warrant further investigation. (University Park, New Mexico) (ADP b3-18)

E. Effect of Intestinal Roundworms on Metabolism

Under a cooperative agreement with the North Dakota Agricultural Experiment Station, work was continued,in a study of the effects of gastrointestinal parasitism, on the sulfur content and tensile strength of wool. Relatively parasite-free lambs as nearly identical as possible were separated into three groups. One group was kept as noninfected controls; one group was given 5,000 infective larvae of gastrointestinal nematodes per lamb, and the third group was given 50,000 infective larvae per lamb. Wool samples and blood samples were collected every two weeks during the study. Tensile strength was apparently adversely affected in the 50,000 larvae/lamb group but not in the 5,000 larvae/lamb group. All groups showed a gain in sulfur content of wool during the study, but the control showed the greatest gain and the 50,000 larvae/lamb group showed the least gain in sulfur content of the wool. (Fargo, North Dakota) (ADP b3-7(R)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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SHEEP AND GOAT INSECTS
Entomology Research Division, ARS

Problem. Sheep and goats are attacked by a variety of insects and ticks that are responsible for losses of many millions of dollars annually in reduced weight gains, decreased production and quality of wool, and in deaths of animals from gross attacks and insect-borne diseases. Sheep keds are a particularly serious pest in the northern States and screw-worms in the southwestern States. Fleeceworms, lice, and ticks are important pests wherever sheep and goats are raised. Safer, more effective, nonresidue-forming insecticides are needed to combat these pests. There is a special need to develop systemic insecticides that when given at low levels in feed, salt, or water would effectively control pests of sheep and goats and thereby save growers the expense of rounding up and treating flocks several times a year. New approaches to control, including attractants, chemosterilants, and radiation, should be explored and developed for controlling certain pests, as was done for the screw-worm in the Southeast. The possibilities of controlling insect pests of sheep and goats with insect pathogens, parasites, and predators also need to be investigated. Additional basic studies on the biology of the insects involved are essential for the development of biological and sanitation measures for their control. Research is urgently needed to determine which insects other than sand flies transmit bluetongue and the role of insects and ticks in the spread of other diseases of sheep and goats.

USDA PROGRAM

The Department has a continuing program involving basic and applied research on insects and ticks which affect the health and productivity of sheep and goats. Studies are conducted on the biology, physiology, and nutrition of pests of sheep and goats, particularly the screw-worm and Culicoides gnats, with some attention to sheep keds and lice; on the nature of resistance to insecticides and on the length of time insecticides remain on animal skin and hair; and on the absorption, metabolism, degradation, excretion, and mechanism of action of insecticides on the insects. A program is underway to find new ways to control pests of sheep and goats, with special emphasis on chemosterilants, antimetabolites, attractants, and non-insecticidal materials. Efforts are being made to develop adult screw-worm attractants for determining the abundance of natural populations and for use in baits for control. Research is concerned with the development of more effective contact and systemic insecticides and with studies to devise sanitation or management procedures to minimize or prevent insect reproduction. Primary emphasis is given to the evaluation of new materials that leave small amounts of or no residues and to testing of formulations that will prolong effectiveness against insects and minimize toxicity hazards. Studies are conducted to determine the occurrence of residues

in tissues of animals treated with insecticides in cooperation with the Animal Disease and Parasite Research Division. A limited program is being conducted on the relationship of insects to diseases of sheep and goats, involving experimental transmission from diseased to healthy animals with various species of insects, and insect surveys in epidemic areas. Current studies are centered on the insect vectors of bluetongue disease of sheep. This work is conducted in cooperation with the Animal Disease and Parasite Research Division. The research is conducted in major laboratories in Kerrville, Tex., and Corvallis, Oreg., and in satellite laboratories in Mission, Tex., and Denver, Colo. Investigations on the screw-worm were discontinued at Kerrville in September 1962 and moved to Mission, Tex., headquarters of the Southwest screw-worm eradication campaign. At the beginning of FY 1963 the bluetongue transmission research was transferred from Kerrville, Tex., to Denver, Colo.

The Federal scientific effort devoted to research in this area totals 4.9 professional man-years. Of this number, 1.9 is devoted to basic biology, physiology, and nutrition; 1.4 to insecticidal and sanitation control; 0.4 to insecticide residue determinations; 0.4 to insect sterility, attractants, and other new approaches to control; 0.6 to insect vectors of diseases; and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology and Nutrition

1. Screw-worm. Investigations included research on the biology and ecology of the screw-worm under field conditions, vigor and longevity of sterilized flies, effects of radiation, development of genetically-marked strains, cytological studies with irradiated flies, nutrition, and special tests related to problems in the sterile male release program.

A new technique to determine the mating aggressiveness of sterilized or mutant screw-worm flies was developed. In laboratory cages males harassed females sufficiently to cause mortality greater than that occurring when females were caged without males - in general, higher ratios of males to females caused greater mortality than lower ratios. Tests with various strains of screw-worms of known sexual competetiveness in comparison with other mating aggressiveness tests confirmed the validity of the method. Since the criterion for mating aggressiveness is the mortality of females over time rather than egg production and viability, the time, space, and labor required to determine sexual aggressiveness were greatly reduced.

Studies confirmed optimum numbers of screw-worm larvae per tray for rearing efficiency and optimum numbers of adults per cage for mating and longevity studies. Diurnal periodicity in screw-worm pupae for

emergence occurred from sunrise until noon. Research has shown that the use of CO_2 as anesthesia for screw-worms is safe for handling young screw-worm adults for longevity and mating tests and scanning for genetic markers.

Research was continued to find and develop genetically distinct strains of screw-worm flies and to study these mutant flies. In the adults many genetic markers were found such as yellow eyes and white auxiliary region ("whaxy"). The genetic marker "whaxy" affects the morphology of both the adult and larva--a factor which would be invaluable in field studies. Approximately 270,000 screw-worm larvae were examined for morphological variants and from this 221 cultures were studied as possible genetic strains. Of markers found in the immature forms, at present three morphological characters--interrupted bands of segmental spines, two spiracular openings in the anal plates of the third-instar larva, and additional spines on the eleventh anterior segmental band--were demonstrated to be genetic in nature. None of these were established as pure strains. The genetics of these and other mutant strains are being determined. The mutant strains must be as vigorous and aggressive as the normal strain if they are to be used in the release program. For example, preliminary genetic studies indicate that the "whaxy" mutant is lethal in the homozygous state with only a few individuals escaping. Other strains appear to have slight behavioral differences from the normal strain, i.e., they responded differently to attractants and survey traps.

When pupae of the screw-worm were irradiated in an atmosphere of CO_2 and air (50-50 mixture), damage to the reproductive system of the adult female was greater than that induced by a similar radiation treatment in air. When the pupae were pretreated in the gas mixture for approximately 45 minutes, complete sterility was induced by a treatment of 4,500 r delivered in CO_2 and air whereas irradiation in air alone required about 5,500 to 6,200 r.

Techniques were developed to study the cytological effects of radiation and chemosterilants on the screw-worm, particularly on spermatogenesis and oogenesis. Preliminary studies revealed chromosomal aberrations severe enough to cause dominant lethality. Considerable data on oogenesis and spermatogenesis in normal screw-worm flies were accumulated as necessary background material for evaluating the effects of radiation and chemosterilants on reproduction.

For rearing larvae of the screw-worm, a synthetic diet was developed that contained casein, yeast extract, cholesterol, inorganic salts, water, and agar. This medium was further defined by replacement of casein with a mixture of L-isomer amino acids, and of yeast extract with a mixture of B-vitamin and RNA. Larval growth and development on the defined medium were nearly equal to that on media containing casein

and yeast. Larvae absolutely required thiamine, riboflavin, pantothenate, niacin, and choline for growth. Biotin and folic acid stimulated growth and were necessary for maturation to the adult stage. Pyridoxine and its analogs, pyridoxal and pyridoxamine, inositol, B_{12}, and carnitine had no effect on growth. Niacinamide replaced niacin, but p-aminobenzoic acid had no effect on the folic acid requirement.

Studies on the effect of dessication, lack of adult food, reduced temperature, age of flies at time of release, and the effect of all of these factors, on different strains of the screw-worm were undertaken to improve the survival of screw-worm flies released into the hot and dry climate of Texas. Provision of food in release cartons or the judicious use of reduced holding temperatures curtailed mortality prior to or shortly after release. Techniques need to be developed which would allow greater uniformity in age of flies at the time of release. Newly emerged flies carry a food and water reserve that will sustain them up to 24 hours at 90° F. and 30% R.H., compared to only 3 to 4 hours for 2-day-old flies under the same conditions. Selection of flies for individuals more capable of survival under unfavorable conditions has shown promising results.

Extensive studies were made on the ecology of screw-worm flies under field conditions by releasing tagged flies. The flies tended to congregate and disperse along water courses or streams and were capable of travelling distances up to 180 miles in 5 to 11 days. This finding resulted in the addition of strategic releases of screw-worms along water courses and an increase in the effectiveness of the sterile-male release program.

2. Lice. Three species of lice were found on Texas goats in 11 counties, Bovicola limbata (the angora goat biting louse), B. caprae (the goat biting louse), and B. crassipes (the hairy goat louse). These lice were collected from January to April.

Fluctuation in numbers of Bovicola limbata was studied on Angora goats ranging from 4 to 7 years in age. In general, goat herds were lightly infested during the summer and lice did not increase appreciably until fall. The weather was extremely hot and dry from mid-July to September, and the time spent in various immature stages by the lice was prolonged. Thus, high temperatures and low humidities may decrease the lice populations by reducing the number of female lice and lowering egg production and also by prolonging the development of the lice from the egg to the adult stage. The over-all pattern of fluctuation in lice numbers showed a progressive increase after each shearing, although there was a drastic reduction in the number of lice after each shearing, with the greatest reduction in male lice. Lice populations continued lower through 2 or 3 weeks after shearing. Mohair growth averaged slightly over 0.8 inch per month. The number of lice on certain goats declined prior to each shearing and the host-parasite

relationship appeared to be the most important factor determining the number of lice on an animal. For example, on December 1, one goat was in such poor physical condition that it was treated intramuscularly with 20,000 units of penicillin; during January it was isolated from the other goats and fed grain supplement, as well as the standard alfalfa ration. In February, the goat became active and was returned to the pen. Concurrent with the physical improvement, the number of lice declined and continued low. However, on July 13, the sex ratio (females:males) of the lice, usually 2:1 to 5:1, was reversed. The same situation was found on another goat on July 20. Two other goats had moderate numbers of lice in the winter and the numbers were declining prior to the spring shearing. However, the lice increased at the beginning of the hot dry summer weather and were present in high numbers at the fall shearing. The increase in numbers of lice on a few low-resistance goats may account for the rapid spreading of lice and heavy infestation of the herd usually observed in the fall.

Off-the-host studies with Bovicula limbata, held at 95° F. and 75% relative humidity, in a constant temperature cabinet showed the following development times: average number of days in the first instar, 6.3 (range, 5-8 days); second instar, 4.9 (range, 4-6); third instar, 6.6 (range, 5-11). For an adult life averaging 15.5 days (range, 7-29 days), the preoviposition period was 3.5 days (range, 2-5 days). The number of eggs per female averaged 7.6 (range, 2-17). The number of days in the egg stage was 8.4 (range, 7-9 days). In a more limited study on the length of development time in the goat sucking louse, Linognathus stenopsis, the average length of the three instars was 14.5 days. These off-the-host studies were conducted in cooperation with M. A. Price of Texas A. and M. College.

3. Biting Flies and Gnats. Tabanids (horse flies and deer flies), snipe flies, and black flies were serious pests of sheep and other animals in the Coast Range of Oregon. There were several hundred black flies per head, along with smaller numbers of snipe flies and tabanids. For daytime protection from these pests, domestic stock was forced to take shelter and remain quiet in dense stands of timber, or to remain quiet in full sunlight in the middle of open pasture. Entomologists collected 366 blood-sucking flies in one hour on a restrained horse. Little is known about the biology of the snipe flies; a few adults have been collected in emergence traps placed over likely larval sites. A few snipe fly larvae were collected in the spring of 1963. It is not yet known with certainty whether these are Symphoromyia--the genus found annoying as adults on the stock.

B. Insecticidal and Sanitation Control

1. Sheep Nose Bots. In Texas, six yearling lambs were treated with a commercially available Ruelene drench. Three were treated at 100 mg./kg. and three at 170 mg./kg. Six other lambs were left untreated for controls. All animals were sacrificed and their nasal chambers and sinuses

examined for bots. The six untreated lambs had 543 first-instar bots, 13 second-instar bots, and 4 third-instar bots, an average of 93 bots per lamb. The higher dosage of Ruelene killed all bots of all instars, but the lower dosage permitted survival of one first- and one second-instar bot.

2. Lice. In Texas, a spray containing 0.25% of Dilan (1 quart per head at 250 p.s.i.) controlled biting lice, Bovicola crassipes and B. sp., on a flock of Spanish goats, but failed to control sucking lice, Linognathus stenopsis. In Angora goat flocks, Ruelene at 0.25%, diazinon at 0.05%, and Ciodrin at 0.25%, gave excellent control of biting lice, B. limbata. Ruelene also controlled sucking lice, L. stenopsis, but the sucking lice reappeared on the goats treated with Ciodrin after 2 months. Ciodrin at 0.1% did not give satisfactory control of either biting or sucking lice.

Incidental to cooperative studies with veterinarians of the Animal Disease and Parasite Research Division to determine toxicity of some dips to goats, observations were made on the effectiveness of Zectran at 0.25%, Geigy 30492 at 0.1%, and Stauffer R-1504 at 0.5%. All dips were effective against both biting and sucking lice and none of the goats became reinfested through 1 month, at which time the tests were terminated.

Angora goats moderately to heavily infested with biting lice, Bovicola limbata and sucking lice, Linognathus stenopsis, were dipped in various concentrations of Sevin, with and without the addition of the synergist, sulfoxide. The addition of the sulfoxide increased the residual effectiveness of Sevin, as lice were not found on the goats dipped in the combination (0.05% Sevin, 0.05% sulfoxide) until 42 days after dipping. Goats dipped in this concentration of Sevin without the synergist showed lice 7 days after dipping. Tests at various concentrations indicated greater effectiveness against sucking lice than against biting lice. Sevin alone was ineffective against both kinds of lice below a concentration of 0.15%. With an equal concentration of sulfoxide, treatments below 0.1% of Sevin were ineffective against biting lice and treatments below 0.025% Sevin were ineffective against sucking lice.

In Oregon, one hundred milliliters per animal of 2% toxaphene, 1% Famophos, 0.3% Baytex, or 1% Ruelene, were poured along the backs of Angora goats for control of goat lice. Baytex was also applied to one group of goats in a spray at 0.1%. After 3 weeks all pour-on treatments were about equally effective, with the control ranging from 96.4% to 97.6%. The Baytex spray gave 99.5% control.

3. Ticks and Keds. Early in the summer in Texas, three flocks of sheep were found infested with the sheep ked. The older animals were lightly infested, but large numbers of keds were found on the older lambs. One flock of 230 sheep was sprayed with 0.1% General Chemical GC-4072;

another flock of 284 sheep was sprayed with this insecticide at 0.25%. The remaining flock of 120 sheep was sprayed with 0.25% V-C 13. Pretreatment counts of keds ranged from 13 to 123 per lamb in the three flocks. The flock treated with V-C 13 showed complete control 1 day after treatment. GC-4072 was slower in action, the 0.25% spray showing only 33% control 1 day after treatment, but 100% control of the keds 1 week after treatment. The 0.1% spray gave no measurable control the day after treatment, only 14% 1 week after treatment, and only 25% 2 weeks after treatment. However, after 1 month, complete control of keds was indicated.

In Oregon, a small flock of sheep with a light infestation of sheep ked (average 8/head) was treated with one gram of technical barthrin per head. The insecticide was applied as a 5% solution in corn oil with a pump oil can at the rate of 20 ml. (2/3 fluid ounce) per head. Control was excellent (97.5%) with only one live ked remaining after 3 weeks.

C. Insecticide Residue Determinations

1. Toxicology Studies. Work was conducted in Texas in cooperation with veterinarians of the Animal Disease and Parasite Research Division on the acute and chronic toxicity of insecticides and other materials. A summary of the results is presented. Detailed results will be given under Unit 2, Animal Diseases and Parasites, ADP a7-19.

A colorimetric analytical method for studying the toxicology and presence in animal tissues of 2,4-D was successfully developed by using carbon-14 labeled 2,4-D which could be determined with radiation detection instruments at each step of the developing technique. The analytical method which resulted is capable of detecting 0.05 p.p.m. of 2,4-D in animal tissue samples weighing 25 grams.

In studies of the detoxication mechanisms in cattle and sheep, oximes, including 2-PAM chloride, DAM, and P_2S, were used to counteract poisoning by various organophosphorus compounds. The oximes cause a release of the enzyme (cholinesterase) inhibited by this group of pesticides. All three compounds were effective in mild or moderate poisoning. Their action was somewhat slow and atropine sulfate was still required in severe poisoning to gain time for the oximes to work.

Sodium selenite, sodium selenate, and d-alpha tocopheryl (Vitamin E) were effective in several instances of organophosphorus poisoning. Studies are needed to explore the mechanisms by which these two substances exert their beneficial effects.

Studies of lindane sheep dips revealed that improper physical formulations were being employed, permitting the first sheep dipped in a fresh vat to so deplete the fluid that the sheep dipped later were

receiving dangerously small concentrations insofar as control of parasites such as the scabies mites was concerned. Because of the excessive amounts taken out by the first sheep dipped, these animals developed tissue residues far in excess of those normally to be expected.

Residues of 2,4-D in sheep fed the compound at a rate of 2 grams per head per day at Logan, Utah, were determined at Kerrville, using an analytical technique developed by the Kerrville staff. In sheep fed 30 daily doses, kidney, rumen, renal fat and body fat samples showed less apparent residue than did a control sheep. Muscle samples averaged less than 0.3 p.p.m. and liver samples less than 1.0 p.p.m. of 2,4-D.

In animals killed by the insect chemosterilants apholate, aphoxide, and methaphoxide, cytological changes were most prominent in the organs engaged in formation of the white cells of the blood. The changes indicated a severe decrease in ability of the parent tissue to supply the needs of the animals. In other studies, these materials were highly cumulative in effect. Although some studies using low-level feeding are still current and the animals still alive, every dosage thus far tried has ultimately killed every sheep treated, in some cases after one year or more of exposure during which no observable illness occurred.

Thirty-two insecticides, most of them currently under test against livestock insects, were studied. These studies furnished toxicological guidelines for decisions for further development of the materials.

D. Insect Sterility, Attractants, and Other New Approaches to Control

1. Screw-worm. In Texas where studies on the screw-worm were conducted, 57 of 350 compounds screened as candidate chemosterilants caused sterility when administered as topical treatments or fed to adults. Some of the compounds sterilized by both methods of administration. Some of these compounds sterilized one or both sexes completely while others induced only partial sterilization or were ineffective. Tests with tretamine applied topically showed that adult flies could be sterilized when they were 1, 3, and 5 days old with equal facility. Males sterilized with thiotepa survived as well as untreated flies and competed equally with untreated males in mating with females. However, the treated males were not as sexually competitive as untreated males. When a single dose of thiotepa or tretamine, adequate to sterilize either sex, was given in two half-doses 24 hours apart, survival of the flies was not improved and, further, a loss in sterilizing effectiveness occurred. Tretamine and thiotepa completely or partially sterilized screw-worms when puparia were immersed in solutions containing these compounds or were injected with them. With immersion, washing of puparia decreased the sterilizing effect, indicating that the adult obtained some or most of the sterilizing dose as it emerged from the puparium. Aerosol treatment of screw-worm adults with tretamine resulted in almost complete sterility.

Laboratory experiments indicated that ENT-50450 was as effective as gamma radiation in sterilizing screw-worm flies and was superior in its lack of toxic side effects. Females mated to males sterilized with ENT-50450 continued to lay infertile eggs after the initial deposition of eggs indicating that sperm in the spermathecae of females did not recover fertility. Males sterilized with ENT-50450 remained sterile throughout their lifetime.

Investigations with screw-worm flies and aziridinyl-type chemosterilants resulted in the conclusion that the primary influence of aziridinyl compounds on the ovaries of flies 0-4 hours old is the inhibition of oogensis, and of flies 1 day old, the induction of mutations. The effects of the aziridinyl compounds on the reproductive potential of female screw-worm flies were similar to those obtained with gamma radiation.

Studies were conducted to determine the absorption, metabolism, and excretion of a P^{32}-labeled chemosterilant (metepa) applied topically and in the diet of screw-worm flies. When applied topically the material was absorbed rather gradually. The material was metabolized to the extent of 42 and 58% in males and females, respectively, in 24 hours. The principal metabolic products were phosphoric acid and an unknown intermediate. Small amounts of five other intermediates were indicated but were not identified.

In the feeding tests, metepa was absorbed and distributed at about the same rates as in the topical tests. After 24 hours, the degree of metabolism in females was about the same as that in the topical test but, in the males, metabolism was 50% higher than in the topical tests. As in the feeding tests, the main metabolic products were phosphoric acid and an unknown intermediate. Five other intermediates were isolated but not identified. Approximately one-fifth of the applied dose of metepa was excreted.

Approximately 200 chemicals and other materials were screened as attractants for screw-worm flies. Of these, 10 were equal to or better than the standard liver bait and require further evaluation. Mutant strains of screw-worm flies may respond differently than normal strains to attractants since black-mutant flies were not attracted to the standard liver bait.

2. Ticks. Extensive tests were conducted in Texas to determine the effects of different levels of radiation on different stages of the lone star tick. One series of tests with nymphs which had been engorged 2 weeks were exposed to different levels of radiation and the adults subsequently placed on hosts. Adults from nymphs exposed to 500 r or 1000 r engorged but produced no eggs. At a dose of 2500 r adults engorged normally and treated females mated with treated males did not oviposit. One of 8 treated females mated with normal males

oviposited and some of the eggs hatched. When females and males treated with 5000 r were confined on hosts neither sex engorged. Similar results were obtained with untreated males and treated females, but when treated males and untreated females were used 2 of 3 females engorged and oviposited. One of the egg masses was not viable and the other showed only a partial hatch.

Exposure of newly emerged adult ticks to 1000 r and 2500 r did not affect engorgement and complete sterility was indicated in crosses of treated males and females and in crosses of untreated males and treated females. Untreated females mated with treated males produced eggs but none hatched. One of the ticks exposed to 5000 r engorged but it did not oviposit. No ticks engorged after treatment with dosages of 7500 r or 10,000 r.

Some of the adult ticks dipped in concentrations of 0.25 and 0.5 percent of apholate, tepa, metepa, or tretamine were killed, but those that survived engorged and laid viable eggs. Dipping in 1% concentrations of these materials also failed to produce complete sterility but the maximum viability of eggs from females treated with apholate was only 0.25%.

E. Insect Vectors of Diseases

1. Biting Flies and Gnats. Studies were continued in cooperation with the Denver, Colo., laboratory of the Animal Disease and Parasite Research Division, on the transmission of bluetongue disease of sheep. The colony of Culicoides variipennis was less satisfactory than it had been at Kerrville, Tex., requiring studies to improve culture techniques. Techniques were developed for large scale feeding of the insects on embryonating hen's eggs and on various fluids through membranes. An attempt was begun to culture bluetongue virus in embryonating hens eggs. The Culicoides fed readily on allantoic fluid of the eggs. Insects were collected, but are not yet fully identified, from an area of bluetongue outbreak in Montana, Wyoming, and South Dakota.

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Beltsville, Maryland, and at Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 2.7 man-years is concerned with studies related to lamb and lamb products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to lipids are considered briefly in this report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutrient Values of Lamb

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared," was completed and carried through to the galley proof phase. For lamb, a major expansion of the number of meats and meat products has been made.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving the Nutritive Values in Foods," Home and Garden Bulletin No. 90, is in press.

2. Minerals and vitamins. Research to establish the relationship between the age and degree of fatness of animals and the nutrient content of lamb meat was conducted at Beltsville, Maryland, in cooperation with the Animal Husbandry Research Division of ARS and the Livestock Division of AMS. Laboratory analyses were completed on raw and cooked leg and loin cuts for proximate composition, thiamine, riboflavin, niacin, folic acid and pantothenic acid. The mineral element content was assayed using the emission spectrograph for determinations of aluminum, boron, calcium, copper, iron, magnesium, manganese and phosphorus, and the flame photometer for the determinations of sodium and potassium. Results have been analyzed and a manuscript prepared for publication.

3. Proteins and amino acids. A manuscript was published describing a method for assay of alanine using Leuconostoc citrovorum 8081 and including results of analysis of 48 proteins and foods, including lamb leg and loin cuts which contained respectively 0.366 and 0.343 grams of alanine per gram of nitrogen.

4. Biological values. Lipid biosynthesis is being studied as a possible criterion for assessing the nutritional value of foods. Rats developed acute deficiency symptoms when fed a cholesterol-free diet plus an inhibitor of cholesterol biosynthesis. The content of total sterols in their carcasses and tissues was about the same as for control animals fed a cholesterol-free diet. Analysis of the major sterols by Entomology Research Division showed 75 percent of the total sterols to be desmosterol and less than 20 percent to be cholesterol in the carcasses of the inhibitor-fed rats; in the carcasses of control rats 95 percent of the total sterols was found to be cholesterol. A manuscript presenting these findings has been accepted for publication. In other phases of this research, lipid biosynthesis in relation to age and diet is being investigated.

B. Properties Related to Quality and Consumer Use of Lamb

Quality of cooked lamb. An integrated report of research conducted at Beltsville, Maryland, and Davis, California, is in preparation as a USDA bulletin on relationships between age and fatness of animal and the physical composition, flavor, tenderness, and juiciness of cooked lamb meat. Included are data on 1,524 cuts of meat from 286 animals, 4 months to 80 months old, evaluated either raw or cooked. Results of certain aspects of the research on lamb were reported at the International Congress of Food Science and Technology in London, England.

C. Nutrient Functions

Lipids. A better understanding of specific relations between diet, health and longevity has resulted from long-term investigations with laboratory animals fed 29 different experimental diets including animal fats and meat. Both excessive food intake and relationship or balance of nutrients in the diet are implicated in the adverse effects that occurred throughout the life-span of laboratory animals. The studies indicate that genetic strain affects the response to the different diets and thus emphasize the importance of recognizing inherited characteristics in evaluating response to diets. Survival varied even with diets of similar fat and protein content. Differences in serum cholesterol levels of animals showed no relationship to kind or level of fat nor to level of dietary cholesterol.

D. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was $8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions," instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition," through

filmstrips ("Food for the Young Couple"), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U. S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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WOOL AND MOHAIR - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. Synthetic fibers are making increasing inroads into many of the traditional markets for wool and mohair because synthetics are shrink resistant, quick to dry, wrinkle resistant, and able to hold pleats and creases. Despite the superiority of wool and mohair in tailorability, comfort in wear, appearance, and hand, they lack some of the requirements for ease-of-care performance. Moreover, in present processing practices and in many of their uses, wool and mohair are subjected to conditions which result in damage, distortion, or weakening of the fibers, and in undesired changes in performance and appearance of fabric.

Needed are practical modifications that give durably wrinkle-resistant lightweight wool fabrics; fabrics that are more resistant to soil, acids, alkalies, wear, pilling, and abrasion; fabrics that have greater resistance to felting and relaxation shrinkage; and wools durably resistant to yellowing, to insects, and micro-organisms. Needed also are new types of fabrics, woven and non-woven, for industrial and other uses, made from natural wools, blends of wool with modified wools, and with other fibers. Development of new and improved wool and mohair products and processing methods will require fundamental information on the chemical, physical, and structural nature of these fibers. If a stable sheep and wool industry is to be sustained, mills must be supplied with processing information on how to produce new and better wool products more efficiently. Inroads have been made in wool markets because the uniformity of price and quality of synthetics and the detailed information which producers of synthetics supply for processing these fibers on textile machinery for wool makes them easy and profitable to use.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research on wool and mohair is conducted at the Division headquarters at Albany, California; by contract in Lowell, Massachusetts, Durham, North Carolina, and Washington, D. C.; and by grant funds under P.L. 480 in England, France, and Finland. Fundamental research is conducted on wool and mohair to relate chemical composition and structure, molecular structure, physical structure, physical properties, and surface properties of both normal and chemically modified fibers to the performance characteristics of the fibers in yarns, knitted and woven fabrics, and non-woven forms such as felts. Fundamental research is conducted on the chemical modification of wool and mohair to impart resistance to degradation by heat, light, and chemical environments encountered in use, and to improve use properties such as washability, crease retention, wrinkle recovery, and resistance to staining, abrasion, and insect attack. Applied research is conducted to develop practical processes for the chemical or physical

modification of wool and mohair fibers, yarns, fabrics, and felts; to develop processing procedures for the modified fibers; and to develop new and improved products from the modified fibers; all to increase the utilization of wool and mohair. In addition, Department scientists are making every possible effort to bring research results to the industry through technical publications, public service patents, popular articles, TV and radio broadcasts, participation in growers' and processors' meetings, exhibits, mill visits and development trials, and conferences with visiting mill men.

The Federal program of research in this area totals 41.4 professional man-years, including contract research equivalent to approximately 1.7 professional man-years per year. Of this number, 25.9 are assigned to chemical composition and physical properties; 15.5 to new and improved textile products and processing technology. In addition, the Division sponsors research grants under P.L. 480 including two on basic studies and two on application of research findings.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical and Molecular Properties. Basic research is continuing for the purpose of better understanding wools to provide an intelligent basis for modifying and processing them into new and superior products. The rupture of wool fiber components has been accomplished with minimum chemical alteration by ball mill disintegration of wool fibers at low temperature. Extensive chemical and physical measurements of wool protein were made and evaluated with the aid of computers to determine the molecular properties of proteins and polypeptides from natural and modified wools. The fiber surfaces of wool and modified wool were studied by the electroosmosis technique, which showed that the WURLANized wool fiber surface has an increased isoelectric pH. Isoelectric changes are reflections of alteration in fiber-to-fiber interactions responsible for felting and shrinking. Certain wool degradation products, resulting from ultraviolet irradiation, were tentatively identified and accounted for by simple molecular fragmentation, or, in some cases, by oxidation. Basic research on wool is continuing.

Nuclear magnetic resonance was used to study water bound in wool fibers. Data are being obtained to further the understanding of the behavior of specific hydrogen atoms of glycine, and will be used as a model to study similar hydrogens present in wool. Hydrogen bonding is responsible not only for binding of moisture by wool, but also for maintaining helically coiled protein structures and for tying these structures together.

Other reagents for modifying wool were investigated. These include hexamethylene diisocyanate, octadecyl isocyanate, and epichlorhydrin. Such reagents tend to improve wool's resistance to acids, alkalis, and oxidizing agents and to impart varying degrees of resistance to shrinkage. Diisocyanates tend to lower abrasion resistance, apparently because of cross-linking, whereas some monoisocyanates do not impair abrasion resistance. Reagents frequently, but not always, reduce dry and wet strength. Grease wool that contains over 20% water yellows significantly within two weeks at 35° C. The yellowing, which increases with time and moisture content, is effectively inhibited by formaldehyde. The formaldehyde reacts with the wool to increase its resistance to acids and alkalis. Work is now in progress to determine the practicality of formaldehyde treatment.

An investigation of the distribution of sulfur in wool was concluded. The research was conducted at the Wool Industries Research Association in Leeds, England, under a Public Law 480 grant. It led to the discovery of bis(2-amino-2-carboxyethyl) trisulfide in wool hydrolysates and cleared up a puzzling discrepancy in the analysis of sulfur in wool. The sulfur compounds of wool serve as components of the polypeptide molecules and also as cross links connecting the molecules and influence shrinkage, crease retention, wrinkling, etc. Known sulfur-containing compounds could account for only 80% of the total content of sulfur in wool. New sulfur compounds were identified which account for much of the missing 20%.

A study of the sequence of amino acid building blocks in proteins of wools is being conducted at the Universite de Lille, Lille, France under a P.L. 480 grant. A low-sulfur protein has been isolated in more nearly pure form (about 50%, judging from analytical results) than hitherto. It is part of the main fibrillar component of the wool fiber. As such, it participates in determining useful properties of wool such as tensile strength and extensibility. The methods applied are being refined and simplified, and research is proceeding to find how the building blocks of this protein fit together.

2. Physical and Mechanical Properties. Basic physical studies are conducted to establish the mechanical properties of natural and modified wool and mohair fibers to assist in the development of new and improved products and processes. The elastic recovery and resilience properties of WURLAN treated fibers and natural wool fibers were compared. The small amount of polymer deposited by the WURLAN treatment does not change these important properties over an extension range of 2% to 30%. Refinements were made in equipment to measure the fineness of individual wool fibers. A constant stress, fixed-frequency vibroscope has been put into routine use for fineness measurement. With this instrument crimped fibers are uniformly straightened and higher precision in fineness measurements is obtained. This represents an improvement over the standard microscopic measurement which is biased toward the major axis when fibers have

elliptical cross-section. It was demonstrated that the fiber fineness and length distribution characteristics of blended top can be predicted from the characteristics of the components of the blend. In routine fineness determinations, results may be accurately estimated by graphical procedures which eliminate all calculations, save time, and reduce errors.

In studies of the torsional properties of wool fibers, removal by heating or chemical modification of the disulfide cross-links, which are responsible for many of wool's unique properties, led to sharp reduction in modulus (stiffness) and increase in solubility of the fiber in formic acid. Such studies of the contribution of cross-links between wool fiber molecules as they relate to mechanical properties of wool under many solvent-temperature conditions provide information that will suggest structural and chemical modifications to improve specific properties of wool.

3. Effects of Radiation and Other Physical Forces on Wool. Progressive changes were demonstrated in the amino acid composition of wool exposed to ultraviolet light for varying periods of time. The effects of ultraviolet light, X-ray, and mechanical damage on wool were investigated by following color changes and electron paramagnetic resonance spectra of induced free radicals. Wool contains a naturally-occurring, stable, free radical in low concentration. In contrast to this natural free radical, the radicals produced by ultraviolet or X-ray are unstable to heat, water, and oxygen. Ultraviolet light can turn wool green, yellow, or white, the color depending upon the wavelength of incident light and conditions of irradiation. By comparing electron paramagnetic resonance spectra of irradiated wool and irradiated individual amino acids, it was shown that the spectrum obtained with green wool could be accounted for by tyrosine and cystine radicals. On exposure to water vapor or air, the green color changed to yellow in a short time, and the free radical spectrum eventually returned to the stable natural radical. Amino acid analyses of wools which have been extensively irradiated with ultraviolet light showed that glycine and alanine increased slightly while all other amino acids decreased, cystine disappearing completely. Several new amino acids appeared as the result of either methylation of demethylation of a naturally occuring amino acid. The end result of irradiation of wool is to turn it yellow. Intermediate colors have been observed only when conditions of temperature, wavelength, intensity of irradiation and gaseous environment were specifically controlled. Research will be continued on the properties of natural fibers to provide basic information on the ultraviolet degradation of wool that will guide chemical modification to improve its performance.

B. New and Improved Products and Processing Technology

1. Shrink Resistance. Development of an interfacial polymerization treatment for wool textiles to impart shrink resistance was reported last year. This new process, covered by public service patents, has been given the name WURLAN. This process has been developed into full-scale mill application and its importance is best expressed by a recent press release

from a trade association during the past year: "A revolutionary new process for shrink-proofing wool fabrics has been developed by the United States Department of Agriculture, enabling wool clothing of all types to be machine washed without appreciable shrinkage." The American Sheep Producers' Council, representing all segments of the American wool textile industry, is assisting in promotion of the new development, in cooperation with the U.S.D.A., as a part of a continuing program to provide information on the process to consumers. One of the largest wool textile producers in the country is now commercially producing WURLANized wool fabrics. Their production rate will increase markedly when promotion begins in the near future.

Initial developments of the WURLAN treatment were applicable to woven wool textiles. A procedure was subsequently developed to apply WURLAN to tubular knit goods but was not satisfactory unless the tube was opened. But because knit goods are subject to distortion in handling, it now appears best to apply the WURLAN treatment to the wool before it is spun into yarn. This development has now been accomplished on laboratory and pilot plant equipment and is being extended toward commercial-scale equipment. The extension of the WURLAN process to wool top and thus to knit goods will help regain markets that have been dominated by synthetic fabrics in recent years.

Treatment of wool by interfacial polymerization has concentrated on utilizing hexamethylene diamine and sebacoyl chloride to form polyamide 6-10. Research is continuing on alternative monomers for this application. Exploratory studies indicated that bischloroformates, which react with diamines to form polyurethanes on wool, may be superior to diacid chlorides in the WURLAN process in stability and in cost. Potentially cheaper than diacid chlorides, C_4 and C_6 bischloroformates are of primary interest. The C_4-diol is commercially available but the C_6-diol will not be commercially available before 1964. Among other polymers being investigated, modified polyethylenes are of particular interest because they provide good shrink-resistance along with excellent fabric hand. They are, however, difficult to apply. Exploratory research was started on new polymers. The oxidative coupling technique provided a rapid polymerization with commercially available phenolic monomers to yield polymers with properties not realized with vinyl polymers or condensation polymers. Preliminary investigations also were initiated on the grafting of collagen onto wool. Because collagen is commercially available and inexpensive, it could be an alternative and cheap finishing agent if grafting to the wool could be effected.

An analytical method suitable for mill use was developed to measure the amount of polyamide or polyurethane on a wool fabric and to distinguish between these two polymers. This method has special industrial interest because it offers a rapid and easy means to identify polyamide resin on the fabric and to determine the amount deposited in the WURLAN treatment of wool. It offers a suitable analytical quality control method for commercial WURLANizing.

2. Uniformity, Strength, and Nature of Yarns. The mechanism of lubrication of worsted yarns is being investigated by the Hosiery and Allied Trades Research Association in Nottingham, England under a P.L. 480 grant. Yarn is waxed and lubricated to impart an improved knitting behavior and appearance. In the early stages of this investigation it became obvious that a hitherto unsuspected factor obscured the true nature of the mechanisms involved in the waxing process. Evidence indicated that the natural oil and grease content on the yarn was higher than the amount of added wax and influenced the lubricity in an uncontrolled way and interyarn friction increased as wax pickup increased although the intent of waxing was to lessen such friction. Further work was conducted using deoiled yarn and the effect of waxing studied further. Wax melting point, temperature of waxing, yarn tension, and yarn speed affect the wax uptake by the yarn. Yarn flexural and torsional rigidities were found to be unrelated to wax pickup. A new apparatus was constructed to allow simultaneous waxing, measurement of friction, and knitting of yarn. Preliminary data indicate large differences between yarn to steel friction in knitting of waxed and unwaxed yarns with the wax reducing friction. Work will continue to obtain more significant data relating waxing to performance.

Studies on the uniformity and strength of yarns made from domestic wools of known history and selected fiber qualities were concluded. These studies were made to determine processing efficiency as related to fiber qualities. Spinning efficiency improvement by WURLANizing wool top was observed, making it desirable to study further of this approach to improving yarn strength before continuing basic studies on the effect of fiber qualities on spinning efficiency.

3. Fabric Construction. Both yarn and fabric construction greatly affect the performance of fabric and the response of fabric to chemical treatments to impart easy-care properties. The emphasis in research for the past year has been on the effects of the WURLAN treatment on mechanical processing characteristics. When WURLAN-treated wool top is spun, some of the deposited polymer tends to dust or flake off during gilling, drawing, and spinning, the amount depending upon the reagents and conditions used in the treatment. Oiling of the stock reduced dusting. More force is required to draft WURLAN-treated top or sliver than untreated top or sliver. Limited tests show that yarns from WURLAN-treated stock have higher tensile strength and slightly higher elongation at break than comparable yarns from untreated stock. No undue difficulties were found in spinning treated fibers, and present indications are that WURLAN treatment reduces yarn breakage during spinning.

4. Fluorochemical Treatment of Wool. Research has revealed a way to chemically graft a fluorine-containing resin to fiber surfaces. The new treatment makes wool oil and water repellent and resistant to shrinkage during machine laundering. The fabric has greater stability under acidic, alkaline, and bleaching conditions. By chemically anchoring the resin to the wool fiber, a durability to cleaning and abrasion was obtained. Cleaning and abrasion wore down all previous water and oil repellents.

5. Durable Creases in Wool Fabrics. Following extensive screening of chemical finishes for imparting durable creases to wool fabrics, ethanolamine in dilute aqueous solution was preferred. Research was concluded with this finding. Trials conducted by informal cooperation with the Quartermaster Research and Engineering Command proved the suitability of the ethanolamine treatment for military garments. Department scientists have provided specific processing directions to the defense supply agency in Philadelphia which has obtained equipment for treating garments with ethanolamine. The treatment will be written into the specifications for military garments as soon as the Quartermaster receives from the Surgeon General the final approval for the treated fabrics.

6. Bleaching of Wool. Research on procedures for bleaching wool is being conducted under contract by the Lowell Technological Institute in Lowell, Massachusetts. In present commercial bleaching treatments wool loses strength and resistance to alkali damage. The present contract investigation is defining limits for safely bleaching wool with hydrogen peroxide. Wool was bleached with peroxide in less than an hour at 120° to 160° F. at a pH of 9 to 10; however, the alkali solubility of the bleached wool increased at least 10%. Better reflectance without increased alkali solubility was obtained when the wool was reduced and cross-linked prior to or during the bleaching.

7. Improved Finishing Treatments for Wool Fabrics. The influence of different wool finishing procedures on fabric properties are being investigated by the Textile Research Association in Helsinki, Finland under a P.L. 480 research grant. Wool fabrics of three different structures were woven from three different grades of wool top. Half of each of the fabrics was woven from top-dyed yarn and the other half was piece-dyed. Progress indicates that the dyeing process can set the wool to desired smoothness similar to that obtained by special setting treatments. The best results with regard to surface smoothness after wetting and to evenness of dyeing were obtained when fabric was first open width scoured, then crab set or chemically set, and finally dyed in a strong acid dye bath. Only by thorough crabbing or chemical setting prior to rope dyeing could rope marks or weave distortion be avoided. The wool lost tensile strength when chemically set and dyed in a strongly acid bath. Neither scouring nor setting caused appreciable damage to undyed wool. Dyed pieces have not yet been tested. Experiments to devise a more effective setting process are being continued in attempts to produce, from coarser grades of wool, fabrics closer to those from finer grade wools. Coarser grades here refer to wools of 62's grade and coarser.

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CLOTHING, HOUSEHOLD TEXTILES, AND FABRICS FOR CONSUMER USE
Clothing and Housing Research Division, ARS

Problem: Decision-making by consumers is becoming more and more difficult as a result of the ever increasing variety of clothing, household textiles, and fabrics for home sewing. The Textile Fiber Products Identification Act which became effective in March 1960 makes mandatory the labeling of textile products as to fiber content, but this only partially solves the problem. To obtain maximum benefit from such labeling, consumers need information on the properties imparted to textiles by cotton, wool, different classes of manmade fibers, fiber blends, fabric constructions and finishes, and on the properties textiles need in order to perform satisfactorily in specific uses. They need to know what types of construction are suitable for use with various fabrics and for different purposes; and how to alter or repair items when necessary. They want garment features that contribute to the comfort, safety, and efficiency of the wearer, and which provide other functional characteristics. They also need systems of sizing of patterns and readymade garments which will assure good fit with a minimum of alterations or return of goods.

USDA PROGRAM

Physical properties of wool fabrics are investigated in relation to construction and finish, and to their performance in use as clothing or household textiles. Improved methods for making clothing and household textiles from modern wool fabrics are sought. Anthropometric data are obtained as a basis for the sizing of apparel.

The Department's research facilities are located at Beltsville, Md. The Federal scientific effort devoted to research directly related to wool totals approximately 0.5 professional man-year.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

As a necessary preliminary to research to obtain much needed information on the elastic recovery and dimensional stability of wool knit fabrics, and the factors which affect these properties, procedures for evaluating knit fabrics with respect to elastic recovery were investigated and a report of the findings is being prepared.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. 1962. Wool fabric stabilization by interfacial polymerization. Part III. Polyurethanes. Textile Res. J. 32(9), pp. 743-750.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. June 11, 1963. Shrink-proofing wool with interpolymers. U.S. Patent No. 3,093,441.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. Feb. 26, 1963. Shrink-proofing wool with polyesters. U.S. Patent No. 3,079,216.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. Feb. 26, 1963. Shrink-proofing wool with polycarbonates. U.S. Patent No. 3,079,217.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. April 2, 1963. Shrink-proofing wool with polyureas. U.S. Patent No. 3,084,019.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. April 2, 1963. Shrink-proofing wool with polyurethanes. U.S. Patent No. 3,084,018.

III. MARKETING AND ECONOMIC RESEARCH

WOOL AND MOHAIR - MARKET QUALITY
Market Quality Research Division, AMS

Problem.

Wool varies widely in quality factors that affect its value and use. Impurities in grease wool are a major problem, and an objective method of estimating the clean yield of grease wool is badly needed. Also needed are procedures and instruments to measure accurately the fineness and length of fibers. Animal fibers in raw or manufactured form are subject to damage by fabric insects, which are estimated to cause annual losses of about $350 million. Effective and safe control methods are needed to be used in homes, retail stores, warehouses, woolen mills, and manufacturing plants to control the fabric insects that infest the premises. Improved fabric treatments and methods of application are needed to prevent the extensive feeding damage by insects. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information leading toward the development of better preventive treatments, and as an aid to the Western Utilization Research and Development Division in its program on the improvement of wool by molecular modification. Urgency is attached to the need for the development of safe and effective mothproofing treatments as a result of the concern about pesticide residues in clothing expressed by the President's Science Advisory Committee in its 1963 report on the use of pesticides.

USDA PROGRAM

The Department has a continuing long-term program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool, mohair, feathers, animal hair, and articles made of these fibers against insect damage while in marketing channels, in military uses, and in the home. The research is conducted in cooperation with the Armed Forces Pest Control Board, the Piano Technicians Guild, and various industry groups. Some work on quality evaluation of wool is also done.

A P. L. 480 contract with the Shri Ram Institute for Industrial Research, Delhi, India, provides for studies in the "canary coloration" of raw wools. Its duration is 5 years, 1963-1968, and involves P. L. 480 funds with a $98,454 equivalent in Rupees.

The Federal scientific effort devoted to entomological research in this area totals 2.6 professional man-years divided as follows: insecticide evaluation 1.9 and insecticide residue analysis 0.4 at Savannah; and program supervision 0.3 at Hyattsville, Md.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. This is a new research project to be carried out under P. L. 480 funds in India. "Canary yellow" coloration of raw wool is an economic problem in both the United States and India. The research will provide basic information on the chemical nature of this coloration of raw wools, particularly regarding the role played by suint (dried perspiration) and its components, wax, and the keratin macromolecule itself in the presence of heat, light, and moisture. (A7-AMS-12(a))

B. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory biological tests were completed with 46 compounds to determine their efficacy in protecting woolen cloth against fabric-insect damage. Sixteen of the 46 were quaternary ammonium compounds and represented exploration of groups of less toxic chemicals for mothproofing, even before the President's Science Advisory Committee expressed concern over pesticide mothproofing residues in clothing. All 16 compounds provided a very high degree of protection against insect damage to the test fabric. When applied to wool cloth at 1.0 percent by weight in an emulsion bath, they showed excellent retention on the fabric through repeated drycleanings. Many quaternary ammonium compounds are commonly used as emulsifiers, bactericides, algaecides, or deodorants. (MQ 1-26)

Studies with cationic quaternary ammonium surfactants showed that deposits of the benzyl types in wool cloth were more resistant to drycleaning than were deposits of the difatty types. Although the benzyl types did not completely protect wool cloth from insect damage, treated cloths subjected to 10 drycleanings incurred no

more damage in tests than did treated cloth in the precleansing tests. It was found the temperature of the application bath for benzyl-type quaternaries is not a critical factor for retention through drycleaning. The compounds were equally effective at all application temperatures of 100° F. or above. This is in sharp contrast to some fabric treatments that must be applied in a bath at 212° F. for adequate retention. Dye-bath applications of the benzyl-type quaternaries in combination with various insecticides showed that the quaternary by itself is more effective than the combination in protecting against insect damage, even after as many as 20 drycleanings. (MQ 1-26)

Further tests were conducted on the application of insecticides to wool cloth, in combination with various textile treatments to determine whether greater resistance to cleansing could be produced. Among the treatments tried were an oil- and water-repellent, a copolymer latex dispersion, and a melamine-formaldehyde precondensate resin. None of the combinations was any better than the insecticide alone. (MQ 1-26)

Followup studies with allethrin applied under dye-bath conditions showed that treated wool cloth was adequately protected against insect damage after 3 launderings and drycleanings. Preliminary tests with anionic surfactants show that those which are intermediates of alkyl aryl sulphonic acid have mothproofing properties when applied to wool cloth in dye-bath treatments. (MQ 1-26)

Studies are in progress with wool cloth impregnated with DDT at the Quartermaster Research and Engineering Center under standard procedures for dyeing piece goods. These studies were initiated because results of small scale laboratory tests conducted at Savannah showed that DDT deposits in wool cloth were highly resistant to cleansing when the DDT was applied under dye-bath conditions of pH2 and a water temperature of 212° F. Preliminary results of the current studies indicate that an application designed to impregnate the fabric with 0.2 percent by weight of the cloth will give satisfactory protection against insect feeding, according to CSMA standards, after 3 launderings or 10 drycleanings. A deposit of 0.3 percent of DDT by weight of the cloth gives satisfactory protection against insect feeding after 5 launderings or 10 drycleanings. (MQ 1-26)

Field studies were conducted in cooperation with members of the Piano Technicians Guild to determine the relative value of two insecticide formulations developed by the Savannah laboratory for the protection of piano felts. The formulation containing lindane, DDT, and Strobane was the more promising.
(MQ 1-26)

Much of the cross-commodity insecticide evaluation conducted at Savannah has significance to this area of work and is reported in Area 13.

2. Insecticide Residue Analysis. Some chemical analyses are conducted specifically for the fabric-insect project. The overall program of analytical work is reported in Area 13.

SHEEP AND WOOL - MARKETING FACILITIES, EQUIPMENT AND METHODS
Transportation and Facilities Research Division, AMS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities needed - such as livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

USDA PROGRAM

The Department has a continuing long-term marketing research program involving industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meat packers and wholesalers, and wool warehousemen. Livestock market research is carried on at Washington, D. C. Part of the work in this area is being done either under contract or in cooperation with the Toledo Scale Corporation, Toledo, Ohio, and the Central Missouri Livestock Auction, Mexico, Mo. Work on the behavioral patterns of livestock is under a contract with the American Research and Mfg. Corp., Rockville, Md. The research on livestock slaughtering and on meat packing and wholesaling at Stillwater, Okla., is cooperative with the Oklahoma Agricultural Experiment Station. Wool warehouse research is carried on at Washington, D. C.

The Federal effort devoted to research in this area totals 6.3 professional man-years; 3.1 man-years (including 2.1 man-years of contract work) on livestock marketing, 2.3 man-years on meat facilities, 0.2 man-year on wool warehouses, and 0.7 man-year on program leadership.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Layouts and Work Methods for Wool Warehouses

At Washington, D. C., a manuscript entitled "Reducing Costs of Grading Wool in Warehouses" was completed and published.

Work on a second study covering layouts and operational guides for wool warehouses of selected storage capacities is about 75 percent complete. The study shows that costs of handling wool can be reduced $1.48 per 1,000 pounds in a warehouse having a capacity of 500,000 pounds of wool; $2.43 per 1,000 pounds in a warehouse having a capacity of 1,000,000 pounds; and $2.80 per 1,000 pounds in a warehouse having a capacity of 2,000,000 pounds from the costs in many existing facilities. Most of the savings are in labor costs and stem from improved layouts, the use of labor-saving equipment such as clamp trucks and conveyors, and adjustments in job assignments within the crews used to perform the various operations.

Suggested layouts based on the lowest cost methods and equipment currently used for receiving, handling, grading, packaging, storing, and loading out wool are provided for warehouses having capacities of 500,000; 1,000,000; and 2,000,000 pounds of wool. A suggested method for expanding each layout to handle a 50-percent increase in volume, at minimum construction costs and without disrupting the flow of wool through the facility, is also provided.

B. Layouts and Work Methods for Hotel Supply Houses

At Stillwater, Okla., a draft of a report entitled "Hotel and Restaurant Meat Purveyors - Custom Service Houses - Improved Methods and Facilities" was tentatively completed and reviewed by operators of custom service houses prior to its submission for clearance for publication. The reviewers made a number of recommendations which should make the report of more value to and more easily understood by the operators of hotel supply houses. At the end of the year the report was being revised to include their suggestions. Progress on a similar study of frozen portion control hotel supply houses includes the tabulation of all field data and the determination of the composition of products to be fabricated by a house handling an assumed annual volume of 3,900,000 pounds.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Layouts and Work Methods for Wool Warehouses

Webb, Tarvin, F., January 1963. Reducing Costs of Grading Wool in Warehouses. Marketing Research Report No. 575.

COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 man-years are on the cooperative marketing of citrus, 2.7 to cotton, 3.5 to dairy, 1.0 to deciduous fruit, 0.2 to forestry, 1.9 to grain, 2.6 to livestock, 1.3 to oilseeds and peanuts, 1.0 to potatoes, 2.7 to poultry, 0.2 to rice, 1.0 to sheep and wool, 0.1 to sugar, 1.0 to tobacco, and 1.0 to vegetables.

Research also is conducted under contract with land-grant colleges, universities, cooperatives and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Carolina, North Dakota and Oregon, and by two private research companies.

In addition, 15 case studies of individual or groups of cooperatives were completed. These were concerned with the improvement of operating methods and the feasibility of coordinating the marketing of two or more cooperatives.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Sheep and Wool

1. Improving operating methods. Work was completed on a study of the operations of a wool marketing cooperative in the Midwest. The report contained information that will be helpful to other wool marketing cooperatives in improving their operations and member services. Information was provided to several wool marketing cooperatives to help lower costs of handling producers' wool through better wool preparation, grading, improved handling facilities, and transportation.

Work was initiated on factors influencing wool marketing decisions of Iowa farmers. This study, being done under contract with Iowa State University, will determine and analyze factors that influence Iowa growers in making their wool marketing decisions, and will develop guides for farmers and marketing firms to use in improving wool marketing efficiency. Results of this study will be applicable to other fleece wool States where marketing problems have hindered the growth of cooperative wool marketing.

2. Analysis of wool pools. Work continued on preparation of a report on findings of a study on the organization and operation of local wool pools in the United States. This method of marketing wool cooperatively appears to be adaptable to many areas of the country where it is not now being used.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Sheep and Wool

Hodde, W. L. 1963. The Wool Department of the Indiana Farm Bureau Cooperative Association, Inc. FCS General Report 113.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side, where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

USDA PROGRAM

The Department has a continuing program to determine the reason for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because more than 50% of the consumer's dollar spent for meat products goes for marketing activities, this work encompasses a wide range of subject matter.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities.

A. Market Potentials for New Products and Uses

The Department has a continuing long-term program involving agricultural economists, economists and personnel with dual economic and technical training engaged in research to bridge the gap between laboratory developments and commercial adoption so as to assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and

expanded markets that new products and new uses can afford. Research is carried on in industrial and food uses at Washington, D. C., and five field offices -- agricultural economists are located at each of the four Utilization Research and Development Divisions, New Orleans, La.; Albany, Calif.; Philadelphia, Pa.; and Peoria, Ill.; and at the Hawaii Agricultural Experiment Station, Honolulu, Hawaii.

Of the Federal effort involving 20.5 professional man-years, 4.2 are devoted to animal products.

B. Economics of Product Quality

The Department's program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups. Work on all commodities is carried on in Washington.

Of the Federal effort involving 14.3 professional man-years, 0.9 are devoted to sheep and wool.

C. Marketing Costs, Margins, and Efficiency

The Department has a continuing long-term program of research in marketing margins, costs, and efficiency designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing practices, affecting costs of marketing through all important trade channels and types of firms and for all farm products marketed in commercial volumes. Most of the research is problem-solving in nature, and is conducted by professional agricultural economists. Some studies are conducted in close cooperation with agricultural engineers and members of other disciplines. In nearly all studies close cooperation is maintained with industry and trade groups and with private firms that generously provide essential data and make plant facilities available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several States. These agricultural economists work closely with State agricultural experiment stations which also share a part of the expense of the cooperative studies.

Of the Federal effort involving 42.2 professional man-years, including cooperative agents paid mainly from Federal funds, 1.0 is devoted to wool.

D. Information, Outlook, and Rural Development

The Department's research program concerning marketing information, outlook, and rural development includes situation and outlook reports concerning prices, costs and margins, employment, marketing services, market structure, means of collecting and disseminating market information, and feasibility of investments in rural areas.

The Department's continuing program of economic research relating to marketing information, outlook, and marketing aspects of rural development is conducted mainly at Washington, D.C.; work on marketing information is conducted at Baton Rouge, Louisiana, Manhattan, Kansas, Columbia, Missouri, Madison, Wisconsin, and University Park, New Mexico; and work on long-term outlook at Berkeley, California, and Corvallis, Oregon.

Of the Federal effort totalling 13.2 professional man-years, 1.0 is devoted to wool.

E. Market Structure, Practices and Competition

The Department has a continuing long-term program of economic research to assist farmers and marketing agencies to adapt to changes in market structure, practices and competition. Work in this area is conducted at Washington, D. C., at field offices in Berkeley, Calif., and Denver, Colo., at 20 experiment stations under cooperative agreements or contracts, and by a private firm under contract.

Of the Federal effort totalling 42.4 professional man-years, 0.1 is devoted to hides, skins and leather.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Market Potentials for New Products and Uses

Sheep and Wool

1. Foreign materials in domestic wool create problems in processing and use. A study of the effectiveness of a redesigned shipping container in cooperation with Utilization Research and a private firm in reducing the particularly troublesome jute fiber contamination has been completed. The new type container virtually eliminated jute but other jute-like fibers identified as grass fibers from native grasses and forage were present in much greater numbers than jute. These fibers cause a fabric defect problem similar to jute.

2. A new shrink resistant process ("Wurlanized wool") developed by Western Utilization enables machine launderability and could enhance wool consumption. Research was conducted to evaluate the potential application of this process and its probable effect on demand.

The potential application of machine launderability to 100 percent wool apparel has been evaluated for men's, women's, and children's wear items. Men's and boys' sweaters, knit jackets, and jerseys would have more customer appeal in every price line because of the launderable feature. Wool hosiery would become a much more popular item if the machine launderable characteristics were added. Appeal of light weight, single ply all wool fabric jackets would be improved, particularly for boys. Boys' trousers for school and sportswear would become more saleable by the addition of machine launderability. Sport coats, storm coats and men's trousers would not gain in merchandising value because of additional launderability characteristics. Women's slacks, skirts, blouses, shirts, sweaters, jerseys and cardigans would all be more in demand by consumers if they could be machine laundered at home. The laundering feature should be limited in wool dresses to teenage budget and popular price line merchandise. Launderability in children's wool apparel would be an important selling point in most items. Children's coats of heavy fabric would be an exception. This item is too bulky to launder and still have the dressy appearance wanted.

Leather

Synthetics have been substituted for leather in a number of uses. Market research to appraise the probable extent of this competition and means by which leather may better serve market requirements reveals that leather stands at the crossroads. Shoes, luggage, handbags, and a number of other products, once made chiefly from leather are being made in increasing quantities from non-leather material. Leather is striking back through technological improvements aimed at lowering cost and improving quality. Developments to date have been helpful, such as glutaraldehyde tanning and brine curing but leather's hope lies in the achievement through research of major technological gains.

B. Economics of Product Quality

Sheep and Wool

Effects of Lamb Grades. The Federal Standards for lamb effective in 1960 were more successful in describing lamb quality than were the previous standards. The trade appears to be more satisfied with the new Federal lamb grades. The new grades are more widely used than were the old grades. Producers appear to be responding to the change by producing lambs better suited to current consumer preferences.

Price analysis suggests that factors other than Federal grades were responsible for the 1958-61 lamb price decline.

On balance, U. S. grades have a positive effect on lamb marketing. They promote competition and may tend to lower marketing costs. They tend to prevent packers and retailers from widening margins at the expense of their suppliers and consumers. Although Federal grades do not affect all segments of the lamb industry equally, the net impact appears to be favorable from the public interest and overall industry point of view.

C. Marketing Costs, Margins, and Efficiency

1. Marketing Margins and Costs for Fibers and Textiles.

Information on the competitive position of American cotton and wool, marketing margins and costs for cotton, wool, man-made fibers, and textile products, is needed as a basis for appraising the present position of the industry and to indicate means of improvement. Market outlets for American cotton and wool continue to be adversely affected by greatly increased competition from other fibers. Farmers' share of the consumer's dollar paid for cotton and wool products in 1962 averaged greater than in 1961, but substantially less than in the early 1950s. Corresponding proportions for manufacturers of wool fabrics varied irregularly and averaged 15% in 1961. Similar proportions for manufacturers of apparel and household goods increased in recent years and averaged 31% in 1961. Margins for wholesale and retail distribution of textile products increased since 1947 and averaged 41% of the consumer's dollar in 1961.

2. Marketing Costs and Margins for Wool. Wool marketing may cost the sheep producer up to 30 percent of his income from wool. The marketing margins might be lowered considerably if more operations were performed in the producing area rather than in eastern markets. Research conducted under contract with the Ohio Agricultural Experiment Station is complete. Results of this limited study indicate only a slight net benefit from sorting of fleece wools in country warehouses. It appears desirable to sort "off wools" if sufficient volume can be obtained and to select out those fleeces during regular grading operations, which meet the requirements of the limited papermakers felt market. Analysis of data obtained from operators of wool scouring and baling plants in the Western States and selected wool scouring plants located nearer points of manufacture is complete and the results are being prepared for publication. The two most limiting factors affecting the feasibility of scouring wool in the producing area are transportation cost differentials of various locations and ownership of wool at the time of scouring. An equation to predict relative transportation advantages accurately was developed and suggestions are presented relating to methods of operations. The baling of grease wool appears desirable in all but the very smallest of warehouses.

3. Organization, Operation, and Efficiency of Wool Pools. Farmers in the fleece-wool areas (outside the Western States and Texas) who usually market wool in small quantities may benefit greatly if they market wool through local pools. They need information on how such pools should be organized and operated as a basis for action.

Mail questionnaires were sent to operators of all known wool pools in the United States for the purpose of obtaining information on volume of wool handled, number of producers served, selected methods of operation, services and charges, and selling procedures. Preliminary results of analysis of these data indicate that the major problems facing the 235 local pools and their 34,000 members can be attributed largely to a lack of knowledge about, or communication with, wool buyers. Improvements in pool organization and operation are suggested incorporating the views of both the pool members and buyers. However, the problem of allocating returns to individual producers in line with the merit of their clip at a reasonable cost is common, and results of this study are not adequate to provide a satisfactory solution.

D. Information, Outlook, and Rural Development

1. Wool, Influence of Classification and Market Information Services on Prices Paid to Producers

In cooperation with the New Mexico Agricultural Experiment Station, data were assembled concerning wool prices paid to producers and the laboratory determination of quality for some 190 lots. Furthermore, information was obtained for 176 lots of wool at warehouses in North Central and Western States in cooperation with the Livestock Division of the Agricultural Marketing Service. In addition, data were assembled providing prices to growers and subjective evaluations of a large volume of wool sold through warehouses in nine Western States from April to August 1962 and generally to October 1963. These data will be used to determine means of improving the marketing information services for wool.

Preliminary results show that the present wool market news reports, published in Boston, may not accurately be reflecting wool prices in the producing area. Utilization of the Agricultural Marketing Service's livestock reporters to obtain local sales information for inclusion in the Boston report appears desirable.

2. Leather and Competitive Substitutes, Long-Term Trends in their Supply and Demand

Present trends indicate that 60 percent of the domestic shoe production may use nonleather materials by 1970. With such a decrease in domestic demand for leather, half of our total hide supply, estimated at 33 to 35 million hides, may move into foreign markets by 1970.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Sheep

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Henderson, Peter L. December 1962. Response of Lamb Sales to Promotion. Published in 1962 Proceedings Issue of Winter Meeting of American Marketing Association.

Wool

Howell, L. D. August 1962. Hedging Trims Wool Product Costs. Article in Agricultural Marketing.

O'Dell, Charles A. June 1963. USDA Research may Provide Broader Coverage of Nation's Wool Trade. Agricultural Marketing.

Poats, Frederick J. April 1963. Appraisal of Treated Burlap Bags for Shipping Wool. ERS No. 110.

Leather

Sills, Morris W. May 1963. The Domestic Markets for Hides and Leather. National Hide Assn. Training School, Michigan State Univ. (speech)

CONSUMER PREFERENCE AND QUALITY DISCRIMINATION - HOUSEHOLD AND INDUSTRIAL

Statistical Reporting Service

Problem: With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increases returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

In addition to surveys of consumer preferences and discrimination, the Special Surveys Branch also provides consultants and conducts special studies, upon request, for other agencies in the U. S. Department of Agriculture or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The work of the Branch is carried out in cooperation with other Federal governmental agencies; divisions within the U. S. Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land-grant colleges; and agricultural producer, processor, and distributor groups.

Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D. C., which is headquarters for all of the survey work whether it is conducted under a transfer of funds arrangement.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Fibers in young people's clothes

Field work was completed in June 1963 on this nationwide survey of the opinions, attitudes, and preferences of teenage boys and girls about cotton, wool, and man-made fibers in selected items of clothing. The purpose of this study is to provide the cotton and wool industries with information on changing attitudes and preferences so that they can direct their laboratory research and public information efforts more sharply toward strengthening their position with the teenage consuming groups. Pretesting of the interview forms had been completed some time ago but further work was delayed because of the contractor's loss of key staff and other difficulties. Selection of a suitable subcontractor permitted activity on this project to be resumed.

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA PROGRAM

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities has emphasized four broad research areas: (1) measurement of consumer response to price; (2) measurement of the effect of price and other factors on the production and supply of farm products; (3) measurement of the effect of supply and demand factors on farm prices and prices to consumers; and (4) improvement of statistical techniques for measuring economic relationships.

Changes in emphasis are made from time to time to utilize effectively the professional skills available and to adjust to work having the highest priority. The current emphasis is on a comprehensive analysis of the price-making forces in the feed-livestock economy, especially on factors affecting supply. As specific agricultural programs are usually proposed on a commodity basis, the current program is discussed in detail on a commodity basis though much of the actual research is carried on jointly for related commodity groups.

(a) Livestock and Meat. This work involves 1.5 professional man-years located in Washington, D.C. Research on livestock is part of a comprehensive analysis of the price-making forces in the feed-livestock economy. This study gives special attention to the quantitative measures that show what happens to the production of each commodity within the feed-livestock sector following changes in price of one or more of the commodities. The study includes analyses for the United States as a whole and for regions to measure differences in price response and to allow for the important farm and nonfarm alternatives available in each region. The present emphasis is on economic factors that affect the supply and price of beef cattle and the demand for feeder cattle and the interrelations among these factors. Results from the beef, hog and feed grain studies along with analyses for milk, eggs, and broilers will be incorporated into an overall analysis of the feed-livestock economy.

(b) Cotton and Other Fibers. This work involves 1.5 professional man-years located in Washington, D. C. The purpose of this research program is (1) to measure the influence of economic factors that affect consumption of major textile fibers and (2) to measure the economic factors that affect the price, supply, and utilization of cotton and cotton products. The major effort during the past few years has been on research relating to consumption of fibers. This study provided analyses which make it possible to forecast quantities of cotton, wool, and fiber consumption. The present research emphasis is on analysis of price, supply, and utilization of cotton. Over the years, one of the major outlets for raw cotton has been exports. The study will examine factors causing variation in exports and will develop quantitative relations which can be used for forecasting exports of raw cotton. These, along with the developed equations for forecasting domestic consumption, will improve forecasts of the total utilization of cotton.

The program pertaining to commodity situation and outlook analysis includes the regular publication of 11 commodity outlook reports; holding of the Annual Outlook Conference in Washington in mid-November; participation of commodity specialists at regional or State outlook meetings or at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of supply of and demand for the major agricultural commodities; and continuing analysis of the impact of existing and proposed alternative farm programs as they affect output, utilization and prices of these commodities.

The total commodity situation and outlook program currently involves 22 professional man-years.

(a) Livestock and Meat. This work involves 2.5 professional man-years in Washington and 2.0 professional man-years in Denver, Colorado. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of livestock and meats. These appraisals, developments of interest to the industry, and results of special studies are published 7 times a year in regular issues of the Livestock and Meat Situation, in special additional issues as warranted, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Farm Index. A comprehensive analysis of the livestock situation is presented at the Annual Outlook Conference. Outlook appraisals are frequently presented at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply and consumption of livestock and livestock products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Livestock and Meat Statistics is published annually.

A Western Regional Field Office in Denver, Colorado, conducts a continuing appraisal of the conditions important to the range livestock industry of the West. The results of this activity are published monthly in the Western Livestock Round-Up, and supplemented by special releases and special materials circulated to the Extension Marketing Specialists of the Western Region.

(b) Wool. This work involves 1.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of wool and other animal fibers. These appraisals, developments of interest to the industry, and results of special studies are published 4 times a year in the Wool Situation, quarterly in the Demand and Price Situation, and monthly in the Farm Index. Outlook appraisals are presented at regional or State outlook meetings, at meetings of farm organizations, and to various industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply, and consumption of wool and wool textile products. Basic statistical series are developed, improved, maintained, and published for general use in statistical and economic analysis. A Statistical Handbook, Wool Statistics and Related Data, is published annually. Recent emphasis has been directed toward national and international problems dealing with imports and duties; and toward price and utilization studies.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Livestock and Meat Situation and Outlook Analysis

The increase in beef production this year exceeded the increase in demand, and fed cattle prices fell. While part of this drop in the opening months of 1963 was recovered by mid-year, prices of fed cattle remained well under 1962 levels for the second half of the year. Continued large production is expected to cause some further weakening of cattle prices in the first half of 1964. Pork production also increased in 1963 and pork prices averaged lower than a year earlier. Pork supplies in 1964 likely will be much the same as in 1963 and prices are expected to average slightly higher, especially during the winter and early spring months. Liquidation of sheep and lambs, which began in 1960, continued the past year although the rate slowed somewhat. Lamb prices in the first quarter of 1963 were much higher than a year earlier, but in the remainder of the year averaged about the same as those in 1962. Lamb and mutton production in 1964 is expected to be only a little smaller than a year earlier and 1964 may mark the low point in the present downswing. Prices may be about the same as in 1963.

A special situation report on livestock was released in April to help producers, marketers, and consumers to understand and adjust to changes in the economic situation brought about by the sharp decline in fed cattle and hog prices. It presented basic information on the prevailing fed cattle and barrow and gilt price situation and discussed factors that were likely to influence the future.

To gauge the probable future trend in consumption, special analyses were made of the uptrend in beef and the downtrend in pork in the last decade. Emphasis was also given to study of the cattle cycle which began its current upswing in 1959. Long-run projections (5 years) were developed for cattle, hogs, and lambs as part of a set of ERS projections for the farm economy as a whole. Work on seasonal patterns of prices and production for various classes and grades of livestock and livestock products was continued. Other work in progress includes an analysis of the regional distribution of livestock production.

Livestock and Meat Statistics, Statistical Bulletin No. 333, the first master issue since the original comprehensive Statistical Bulletin No. 230, was released in July 1963.

Wool Situation and Outlook Analysis

The U.S. wool industry experienced a relatively good year in 1962, with prices to growers in the open market a little higher than for the larger 1961 output. Mill activity in the apparel wool sector, especially on the worsted system, was the most since 1956, while in the carpet wool sector it was only slightly less than a year earlier. Imports of apparel wool textile products and carpets and rugs were at record high levels. Wool products were further improved by technological advances that provided permanent creasing, wash-and-wear, mothproofing, and other properties to the inherent qualities of wool.

During the early months of 1963, wool prices were at the highest level since the fall of 1957. Prices declined moderately during mid-year as mill demand declined seasonally and inventories of finished wool products increased. U.S. shorn wool production continued to decline in 1963 due to fewer sheep numbers. U.S. mill use of apparel wools is expected to be lower in 1963 than a year earlier, but use of carpet wools likely will increase. Imports of apparel wool textile products continue at a record high level, but due to tariff increases, imports of carpets and rugs are somewhat less than a year earlier.

Many of the factors which were dominant in the world wool situation in the 1962-63 marketing season are also pertinent in the 1963-64 season. Wool carryover stocks in both producing and consuming countries were low. World consumption was relatively stable at record high levels as population

and standards of living continue to increase. Offsetting these factors is the anticipated record high world production of wool and the increasing use of manmade fibers. World wool prices at the opening of sales for the 1963-64 marketing season in late August 1963 were moderately lower than those prevailing at the close of the 1962-63 season but above the opening levels of the previous season.

Analysis of the U.S. carpet wool industry during the last decade reveals many significant changes. The quantity, origin, and grade of U.S. imports of carpet wool varied substantially. The types of fibers used in surface constructions, the production and value of shipments, the width of broadloom carpets and rugs, and the types of carpets and rugs produced also changed considerably. In addition, there were increased promotional activities and technological advances, such as permanent mothproofing, which helped to increase use.

During late 1962 and early 1963, special studies were made relating to foreign trade in wool textile products and their impact on the U.S. wool industry in connection with the Interagency Textile Advisory Committee. Long-run projections (5 years) were developed for wool and wool products as part of a set of ERS projections for the economy as a whole. Technical assistance was given to the U.S. delegation to the International Wool Study Group meeting in London. In addition, quarterly estimates of mill activity in the U.S. wool industry were furnished to the Commonwealth Economic Committee.

Textiles - Supply, Demand and Price

A technical bulletin released in September 1963 develops estimates of final domestic textile fiber consumption in the United States and measures the effect of the major economic factors on variations in consumption. Many of the results were presented during the last reporting period. The new estimates of consumption take into account shifts in the pattern of U. S. foreign trade in textiles, and shifts in the mix of fibers used in the manufacture of textiles to include a greater percentage of synthetic fibers which do not displace cotton and wool on a pound-for-pound basis, and more nearly represent the cotton equivalent volume of fiber used by domestic consumers than the previously used indicator of consumption. The single economic factor found to have the most influence on fiber consumption was level of income. The statistical analyses from this study will make possible better forecasts of consumption of cotton, wool and other fibers.

With the completion of the study of factors affecting the demand for textile fibers in the United States, research has been concentrated on the price and utilization of cotton and cotton textiles, with separate

statistical analyses to isolate the important factors in all major outlets. Preliminary results indicate that the level of United States prices in foreign markets and changes in foreign production and consumption of cotton and synthetic fibers affect United States cotton exports.

Exploratory analyses have been made of the demand for groups of fabrics in the United States such as print cloth, sheeting and narrow fabrics to gain insight into the domestic utilization of cotton.

Estimates of fiber used by the military services have been revised and updated. These estimates are to be published within a few months. Also, conversion factors for estimating the raw fiber content of U. S. exports and imports of textiles are being revised. This revision was made necessary by changes in Bureau of the Census classifications of exports and imports of textiles. Classifications were changed in connection with the International Textile Agreement.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Livestock and Meat

Gerrity, Martin V. August 1963. Common market regulations and U. S. livestock and meat product exports. Livestock and Meat Situation.

Van Meir, L. W. Livestock and Meat Situation. Published 7 times a year. ERS, USDA, Washington, D. C.

Livestock and Meat Statistics. July 1963. ERS Statistical Bulletin No. 333.

Wool

Raymond, C. E. Wool Situation. Published quarterly, ERS, USDA, Washington, D. C.

Raymond, C. E. December 1962. Wool production down, use and imports increasing. Agricultural Situation.

Raymond, C. E. August 1963. Changes in the carpet wool industry, 1952-62. Wool Situation.

Wool Statistics and Related Data through 1962. March 1963. Supplement to ERS Statistical Bulletin No. 250

Cotton and Other Fibers

Donald, J. R., Lowenstein, F., and Simon, M. S. Sept. 1963. The demand for textile fibers in the United States. U. S. Dept. Agr. Tech. Bull.